

november 1957



metal progress



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for high temperature

applications

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Metal Progress

Volume 72, No. 5

November . . . 1957

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*The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1957

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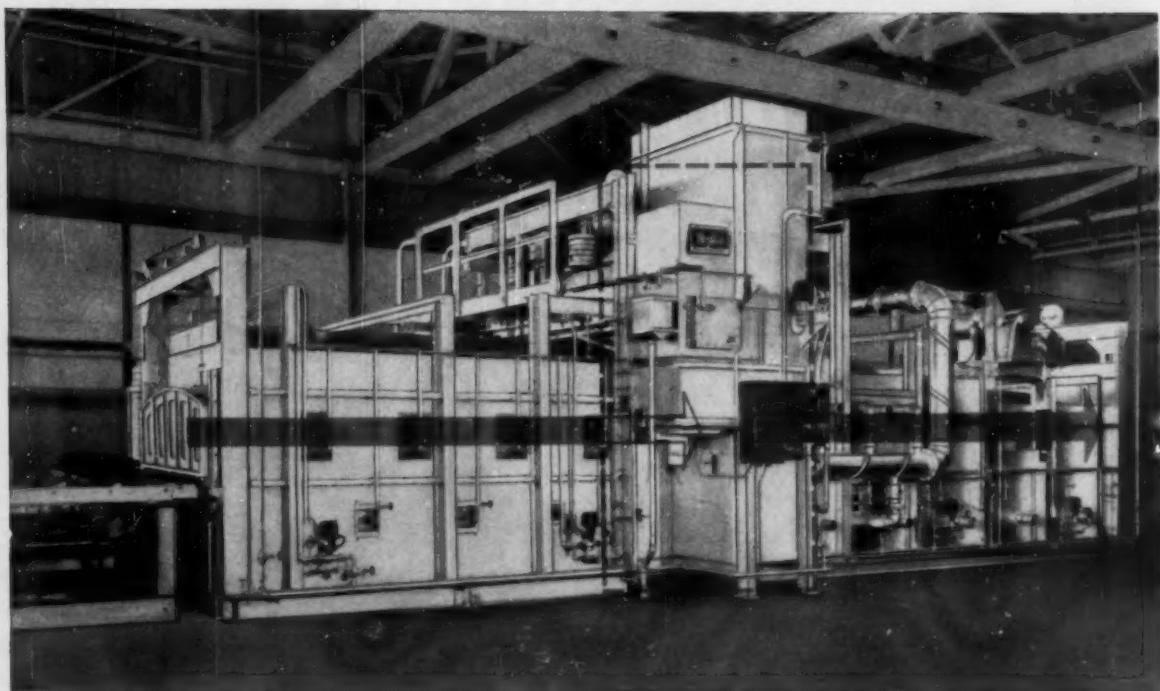
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ELECTRO-ALLOYS DIVISION Elyria, Ohio

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Superfast cooling for cycle annealing



A furnace-within-a-furnace makes this Surface cycle annealer one of the most versatile heat treat units in the country. It anneals, cycle anneals, and normalizes gear forgings of different size, shape, and alloy at the net rate of 864,000 lbs. per month or better.

Such exceptional versatility is achieved by a superfast cooling zone. Really a full convection furnace within a direct-fired furnace, this zone is isolated by refractory doors. It can be used or by-passed, depending on which of many cycles the customer wants. As a result, the customer can heat treat as many as 13 different alloys in this one furnace.

Adding to the flexibility of the furnace is a modular tray design. Each module is an 18x20-inch chrome alloy casting. Modules can be combined to hold any size of work up to 800 pounds. They are also used to carry work outside the furnace.

This furnace-within-a-furnace is another proof that Surface engineers are old hands at creating new ideas in heat treating.

Write for Bulletin SC-146 on cycle annealing.

Surface Combustion Corporation, 2377 Dorr St.,
Toledo 1, Ohio. In Canada: Surface Industrial Furnaces,
Ltd., Toronto, Ontario.

wherever heat is used in industry



As I was saying...

EVERYTHING works out well if you are patient and persevering. Now I recognize that the above should be in quotes but I cannot remember to whom to attribute it. But anyway the A.S.M. Board has been patient and has been keeping right at it to secure from the architect a headquarters design that would be appropriate for the Society — would be original in its concept as a building for a metal society — that would be distinctive, efficient and functional, and would be a source of pride for the 29,000 members.

We worked for over a year with an out-of-town architectural firm and studied some nine projects but could not accept any submitted, not only because all exceeded the budget (\$1,500,000) but they never seemed to be "The Building" we had in mind. So we found it necessary to seek another source for inspiration and design.

It was only a few weeks before our patience was rewarded, and like manna from heaven, there came into our lives John Terence Kelly of the firm of Kelly and Kress and Associates of Cleveland. Mr. Kelly is a young architect, full of pep and vision, with excellent training and with capable assistants, who on his first presentation came up with a design that passed the Board Committee (Young, Lorig, Eisenman) and also received the unanimous approval of the entire A.S.M. Board of Trustees.

The Board selected Gillmore-Olson Co. (of Cleveland) to be the contractor and builder.

The Master Plan has been approved, the Zoning Board of Russell Township (in which the headquarters building is located) has given unanimous approval, surveys have been made, a well is being drilled, and the road leading to the (*Continued on p. 6*)



Messrs. Eisenman and Kelly Examining a Visualization or Diagram of the Main Lines of the New A.S.M. Headquarters' Structure

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site will have its foundation placed this fall so the heavy construction loads can be hauled when spring comes. It will require about 11 months from about March 15 or April 1 for completion.

I want to give you a brief on John Kelly's training. I know you will recognize by his training and travels that he is the "manna from heaven" who has the responsibility of placing the A.S.M. headquarters in a beautiful garden setting.

John Terence Kelly received the B.A. degree from Carnegie Institute of Technology, the M.A. in Architecture from Harvard under Walter Gropius, and the M.A. in Landscape Architecture from Harvard under Hideo Sasaki. In addition he has studied painting, sculpture, and the history of civilization at the Universities of Biarritz and Grenoble. Among honors he has received are the Charles Eliot Norton Traveling Fellowship from Harvard and a Fullbright Grant to study City Planning in Munich, Germany.

Mr. Kelly has had diversified experience with a number of well-known architectural firms. In Cleveland he worked with the firms of Outcalt, Guenther & Associates and Ward & Conrad. In Boston, with the office of George W. W. Brewster, he designed in 1953 the *House and Garden* "House

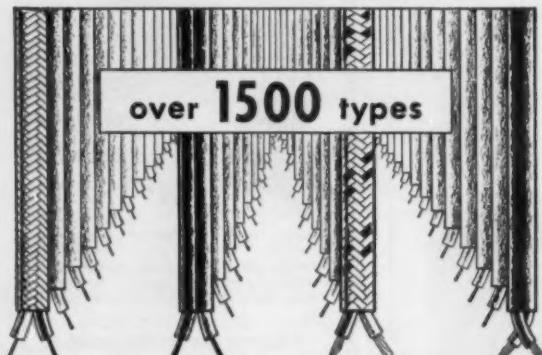
of Ideas", and in 1954 the J. Gordon Gibbs residence which was recognized by the Boston Arts Festival as the best in New England. His partnership with James Nessly Porter produced the "House of the Year", an award by *Progressive Architecture* magazine. From the above you can judge for yourself. It's good news I bring to you and I know you are as happy as we are.

The A.S.M. of Tomorrow has been on its way for some time. The Metals Engineering Institute is now in action with more than 300 students enrolled in the first three months; the advertising campaign will start at the first of the year. The Metallurgical Seminars are in progress and soon the cornerstone of the first unit of the building program will be in full swing. It'll be a great day for all of the A.S.M. when it breaks ground for the first time and begins an era of greater progress for the Wonderful World of Metals.

Cordially,

Bill

W. H. EISENMAN, Secretary
AMERICAN SOCIETY FOR METALS



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Write for T-E Wire Bulletin 31-WS-H.

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The requirements: harden precision-made jet aircraft rings of 410 stainless in a rapid, uniform cooling operation without excessive distortion or carbide precipitation after solution treatment. This firm, well-known for its extremely high standards of quality, reports: "Gulf Super-Quench performs well where other quenching oils have failed, and it completely satisfies all our requirements."

Gulf Super-Quench offers the desirable properties of high initial quenching speed, in the critical hardening range . . . slow final quenching speed, throughout the lower temperature

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New trends and developments for design engineers . . .

How Carboloy[®] cemented carbides' wear-resistance and other unique properties solved three tricky problems

Carbides' low coefficient of thermal expansion keeps tiny parts tiny

The Van Keuren Co., Watertown, Mass., specializes in precision measuring tools, and tiny parts such as bearings and pivots for instruments, components, and missiles.

Dimensions of these parts are often measured in thousandths . . . and their tolerances in millionths.

It's hard enough to make anything as small as the pivot shown in Figure 1, but once it's done, making sure it stays that size despite ambient temperatures and rugged operating conditions is another problem.



FIG. 1 — Carbide pivots measure .0030" in diameter, .0165" in length.

Carboloy cemented carbides were the perfect solution because they do not expand and contract like other materials. Their coefficient of thermal expansion is less than half that of SAE 1095 heat-treated steel.

For example, from 70° to 1292°F., Carboloy Grade 779 has a coefficient of $2.80 \times 10^{-6}/^{\circ}\text{F}$. — compared to $8.20 \times 10^{-6}/^{\circ}\text{F}$. for SAE 1095.

In addition, carbides resist atmospheric corrosion and erosion. They can be lapped and polished to a mirror finish for smooth, accurate bearing action. And they're ideal materials where compressive loads are high because carbides' ultimate limit in compression is 2 to 16 times that of steel.

Carbides' high temperature resistance solves soldering problem for H. & A. Selmer

Soldering clarinet keys in place takes a steady hand with the gas torch, and special jigs for holding and positioning tiny assemblies (Figure 2).

H. & A. Selmer, Inc., leading manufacturer of band instruments had no trouble getting the steady hands. The problem was with the jigs.



FIG. 2 — Carbide points hold and position clarinet key assembly during soldering.

Because of the high temperatures needed for silver soldering the nickel-silver keys, Selmer was using stainless steel jigs. Unfortunately, the keys often ended up soldered to the jig; as well as to their own parts. This meant hours of hand filing, extra cleaning, frequent repairs of the jigs.

Then Selmer engineers introduced the use of Carboloy cemented carbide location points. In addition to being the hardest metals made by man, they have the ability to resist excessive oxidation at temperatures of 1500° to 1600°F.

And, once carbide is coated with a thin layer of oxide, neither the solder, nor the keys, will stick to the holding and location points.

Soldering operations were speeded up; hand filing eliminated; jigs stayed accurate longer—and Selmer's costs came tumbling down.

Carbide's resistance to corrosion keeps printing ink flowing for IBM

When IBM makes IBM cards, it makes them by the millions. And it makes them on special high-speed machines that automatically print, cut, and count 1600 cards a minute.

Each machine has its own miniature printing press. Ink is metered out by stainless steel pump submerged in a well in the machine base.

Wear on the pump parts was problem enough. But the ink was

also corroding its impeller bushings and shaft.

IBM engineers solved the problem by installing Carboloy cemented carbide bushings and shafts.

Normally, carbides are not used for their corrosion resistance alone.

But, as in cases like this, where a combination of corrosion-resistance and wear-resistance is needed, Carboloy cemented carbides can more than pay their own way.

They have good resistance to organic acids, many inorganic acids and bases . . . and are practically inert to attack by salt water spray.



FIG. 3 — Miniature printing press in IBM card machine. Note carbide shearing knives above the printing plate.

Incidentally, IBM is also saving an estimated \$40,000 a year in labor costs for regrinding the rotary shear knives used to cut the cards to length.

By changing to Carboloy carbide knives, 267 million cards are trimmed before resharpening — compared to only 16 million with steel knives.

IBM, Selmer, and Van Keuren each used a different grade of carbide. Because Carboloy carbides are available in 19 standard grades, they could select the grade with exactly the right characteristics for their particular needs.

If you would like additional technical data on the unique properties of this material—or expert assistance on design problems, write: Metallurgical Products Department of General Electric Company, 11167 E. 8 Mile Road, Detroit 32, Michigan.

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to buy. They'll be "preconditioned" — for the great Southwest is on the march, sparking sales to improve its own business economy.

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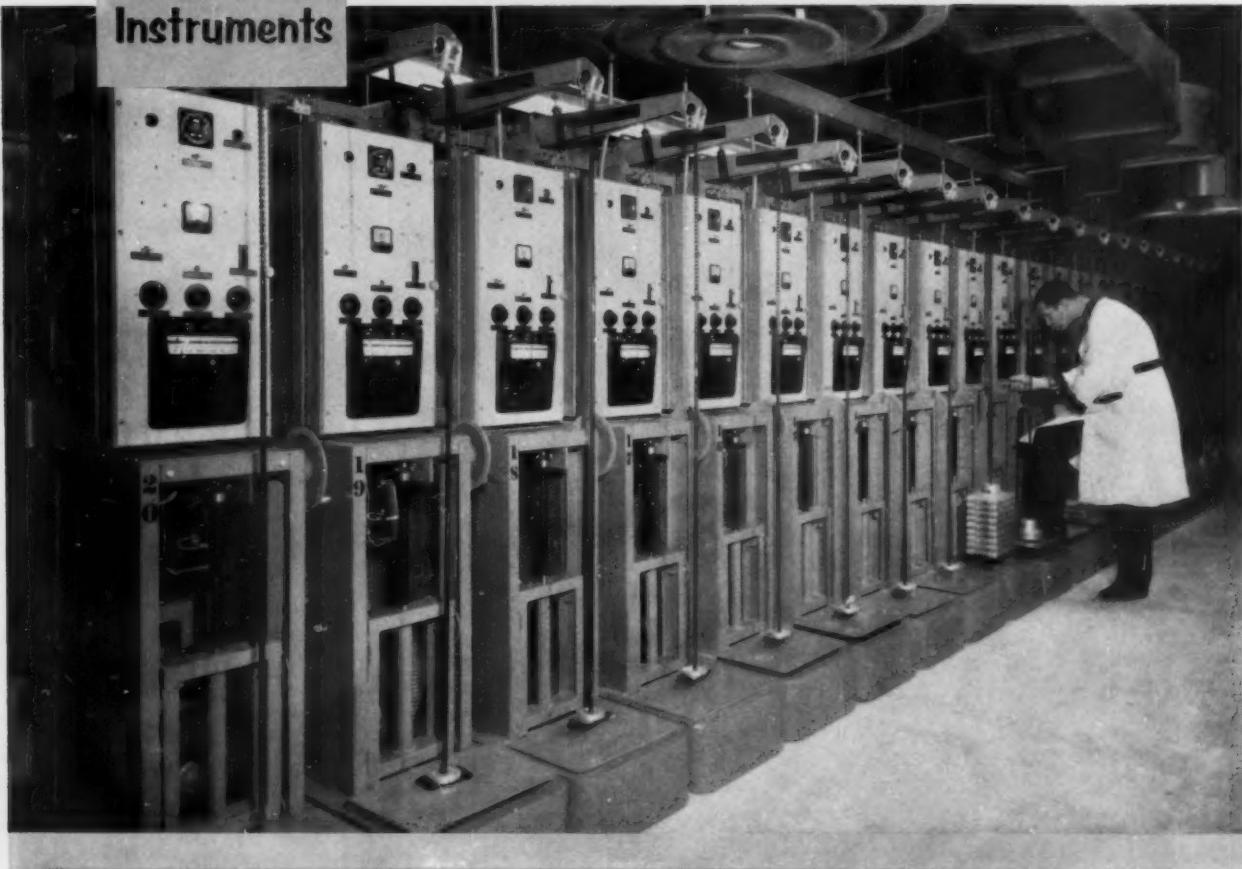
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Instrument standardization shows results in outstanding performance at Joliet Metallurgical Laboratories

It's Wheelco—all the way—in this modern testing installation at Joliet Metallurgical Laboratories, Inc., Joliet, Illinois. Outstanding performance on creep and stress-rupture tests depends in large measure on the proper application of modern instrument standardization in terms of temperature control.

To achieve this outstanding temperature regulation—well within ASTM specifications—Joliet Metallurgical Laboratories chose Wheelco 407 saturable-reactor Capacitrols for use on their Arcweld creep-test machines. Materials tested range from alloys of magnesium, aluminum, and titanium, through the stainless steels to the superalloys—a temperature span from approximately 400° to 2200° F.

Why did an organization with high-performance requirements standardize on Wheelco in this test battery? High degree

of accuracy and reproducibility are the leading reasons—but low initial cost and an impressive maintenance record are extremely important in the decision.

In a test setup like this one, just as in numerous other installations, Wheelco's famous plug-in chassis eliminates countless maintenance headaches. That's why it pays to standardize on Wheelco Instruments. A spare chassis—prechecked and ready to go—can be inserted and the malfunctioning unit taken to the shop for checking under ideal conditions.

You'll find more advanced design features in Wheelco Instruments than in conventional units that only look similar. Your broadly experienced Wheelco field engineer will help you survey your instrument needs and point out where your processing can be improved materially with the proper instrumentation.

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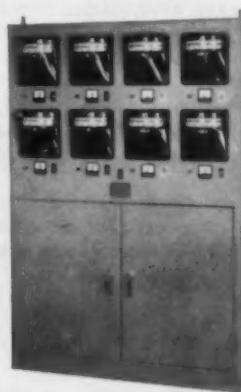
FROM WHEELCO...



Capacitrols—
companion to the 400 Series featured above are these horizontal "Panel-mount" types. Both styles are available in a variety of control forms: time-proportioning, two-position, Multronic, proportional-position, and electrical-proportioning.



Indicating Pyrometers—
built to highest standards for precision instruments . . . feature meter movement with Alnico V magnet and electrical compensators for resistance changes in the metering system.



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rewired, prefabricated Wheelco control provide major savings by simplifying installation and incorporating instruments and accessories in a single unit. Instruments shown here plus any others in the complete Wheelco line can be combined in a single attractive and efficient unit.

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vacuum-melted steel
passed the durability test**



The hook pivot pin in the Aero 15B bomb rack and rocket launcher must be highly resistant to fatigue. To test this property, the pin must undergo 4½ hours of destructive vibration tests. It is subjected to vibration in each of three axes in turn with a frequency of 50 c.p.s. and a total excursion of 0.06 inches while loaded with a 500 pound store. This is no minor point, as the 500 pound store under these vibration conditions exerts a damaging and fatigue effect considerably more than a 500 pound load under any other test condition.

Air-melted steel did not stand up under this rigorous testing. But Ferrovac vacuum-melted 4340 steel emerged without apparent damage.

A vacuum-melted metal with such improved durability and strength may be just what you need when other types can't measure up to your rigid specifications. A VMC engineer will gladly help you explore this possi-

bility. Thus the full technical resources of the first and largest producer of vacuum-induction melted metals will be placed willingly at your disposal. Write—describing your problem—in detail—to Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, N. Y.

Vacuum-melting is adding new performance to these metals.
Do you have an application that may benefit from their use?

High temperature alloys
High strength alloy steels
Low alloy steels for springs
Nuclear reactor materials
Special nonferrous alloys
Alloys for investment castings

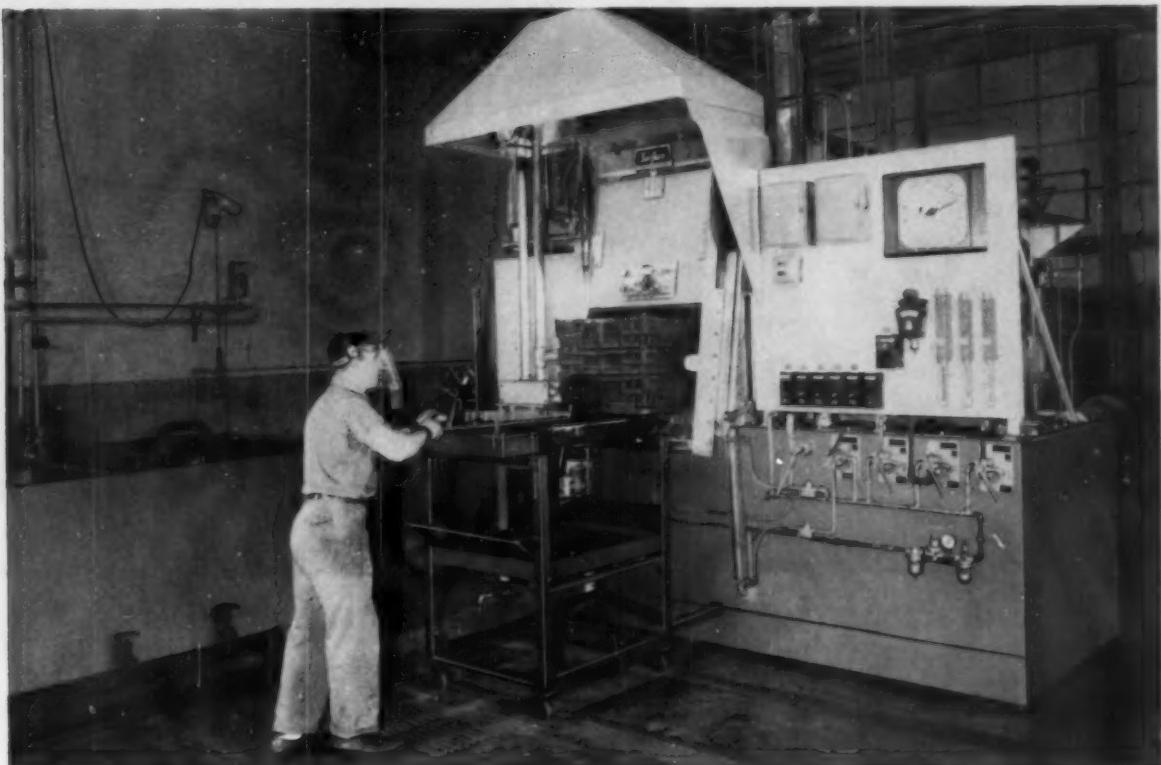
Bearing steels
Tool steels
Stainless steels
Hard facing alloys
Electronic alloys
Soft Magnetic alloys



VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

Allcase® furnace clips cost $\frac{1}{2}$ on manicuring implements



One man and one furnace now match the former production of two men and two furnaces in this plant. Added to this gain are two others: greater versatility in processing, and finished work of uniformly high quality. The latter is especially important to this manufacturer of manicuring implements, because he offers a lifetime guarantee on many of his products.

The "hero" of this story is the Surface Allcase® furnace, which is used for hardening, carbonitriding, carburizing, and annealing. Controlled atmosphere is supplied by a Surface MRX® gas generator. Work handling and atmosphere control can be completely automatic, if you wish. Why don't you find out about this profitable furnace now?

Write for Bulletins SC-163 and SC-174.

Surface Combustion Corporation, 2377 Dorr St., Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

wherever heat is used in industry





The Quench That's Different... Because It Has Safety Factor

There's one *sure* way to get the hardness your heat treating practice prescribes . . . use HOUGHTO-QUENCH Oil.

You get the benefit of a safety factor with HOUGHTO-QUENCH, because it's the fastest quench this side of water. It is extremely stable, will not break down. It has a high flash point. It wets out fast and drains off work fast.

There is so little sludge formed in HOUGHTO-QUENCH that many heat treaters are today using HOUGHTO-QUENCH that was installed before World War II.

Get the details from the HOUGHTON MAN who calls on you.

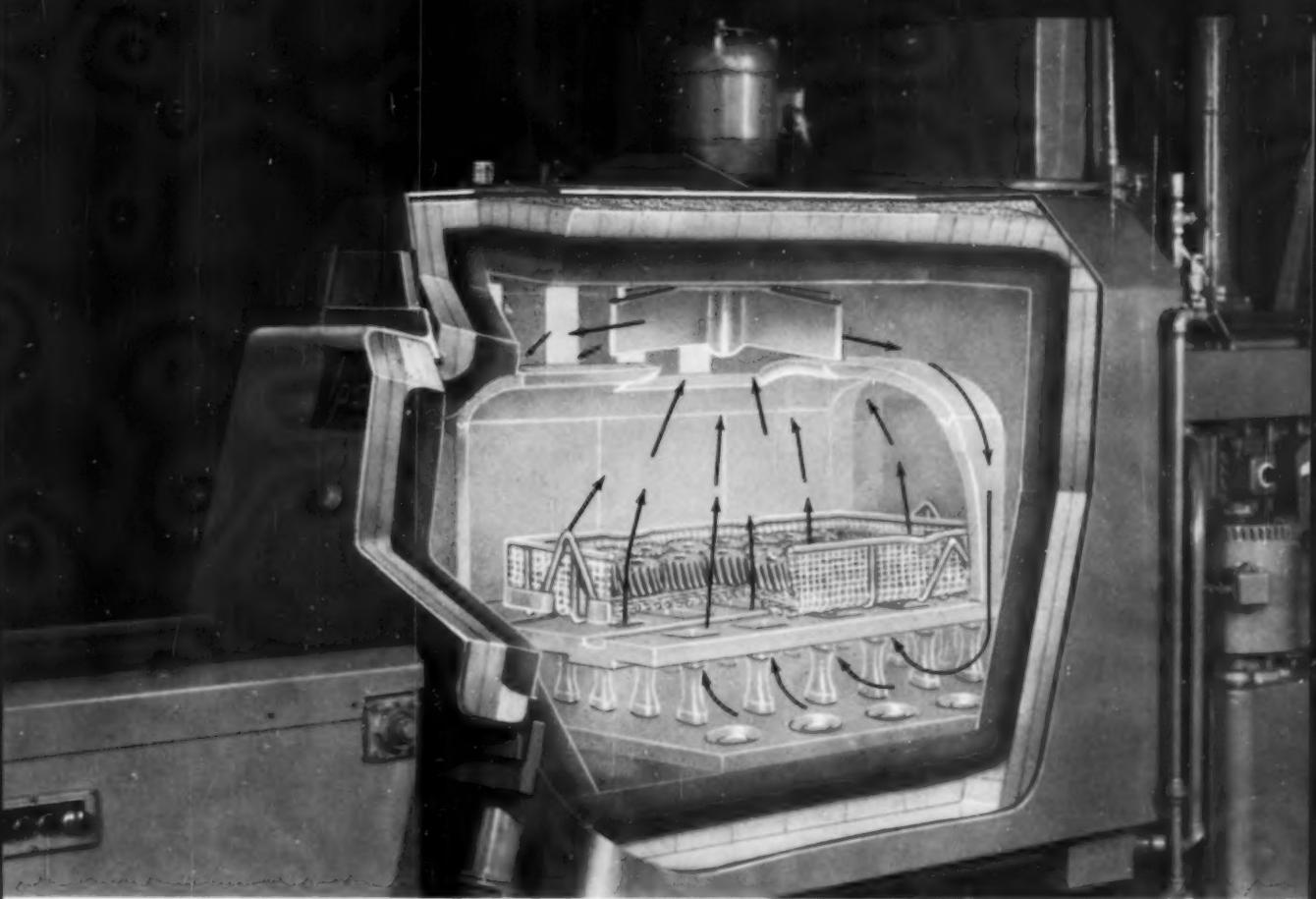
HOUGHTO-QUENCH

..... a product of

E F HOUGHTON & CO.
PHILADELPHIA - CHICAGO - DETROIT - SAN FRANCISCO

Ready to give you
on-the-job service . . .





Superior controlled atmosphere heat treating

... with Ipsen 100% forced convection

100% forced convection heating and exclusive alloyed ceramic heating tubes have been successfully combined in all Ipsen furnaces for special atmosphere carburizing, carbo-nitriding, heat treating, brazing or sintering, and other applications calling for temperatures up to 2500° F.

Here's what happens when a cold charge goes into an Ipsen furnace. Stored heat from the furnace walls is forced into the heating chamber to the work being heated. This causes the furnace temperature to fall until the furnace wall, the heating chamber, and the charge all reach the same temperature. Then the high velocity heat which is carried to every part of the heating chamber and the

charge simultaneously raises the temperature of both the heating chamber and charge back to the desired control temperature.

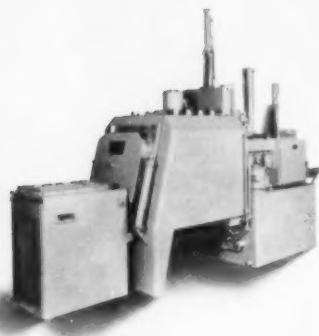
100% forced convection heating insures uniform heating of every part of the charge . . . whether it's loosely or densely packed. Both light and heavy sections are uniformly heated.

Ask for literature describing Ipsen 100% forced convection furnaces.



*following page
shows 100%
forced
convection
chart*

**how Ipsen
100% forced
convection
works . . .**



This centrifugal roof fan, powered by a husky, slow-starting motor, circulates the protective atmosphere . . .

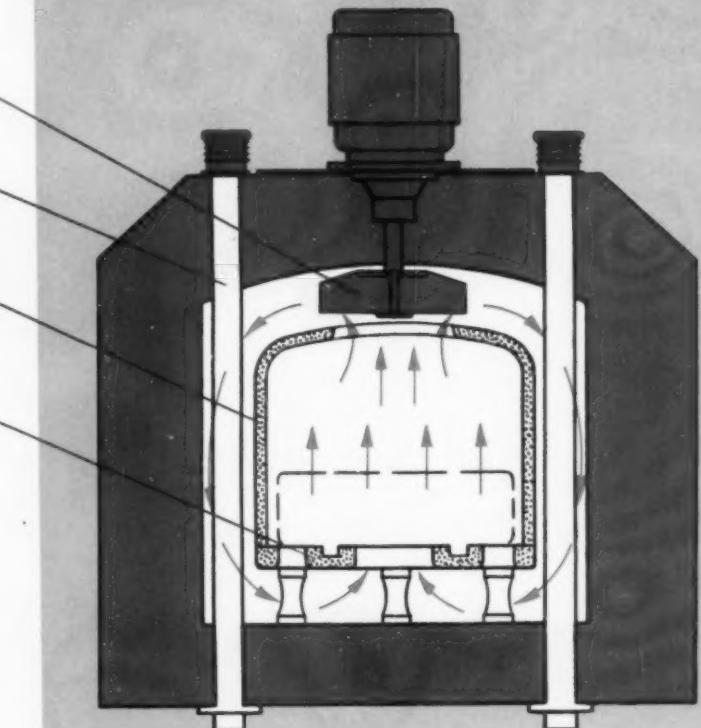
down past these vertical alloyed ceramic heating tubes . . .

which are isolated from the work chamber by this baffle . . .

to the bottom of the furnace and then up through this heavy, open grid-hearth . . .

to all parts of the charge where correct working temperature is maintained.

Work is brought to heat uniformly . . . controlled atmosphere is forced to all parts of the charge.



Write for technical brochures describing
Ipsen 100% forced convection furnaces.



IPSEN INDUSTRIES, INC. • 723 S. MAIN STREET • ROCKFORD, ILLINOIS

Columbia Tool Steels for 1957-58 with A.I.S.I. Identification and Type Classification

GRADE	Type	Identifying Elements, In Per Cent						C	Cr	Ni	V	W	Mo	Co	Cu
		C	Mn	Si											
COLD WORK TOOL STEELS — OIL HARDENING — TYPE SYMBOL 0															
O1		.90	1.00					.50					.50		
O1		.90	1.60					—					—		
O7		1.90	—					.75					1.75		

COLD WORK TOOL STEELS — OIL HARDENING — TYPE SYMBOL 0

MEDIUM ALLOY AIR HARDENING — TYPE SYMBOL A						
ROTHCUT †	A2	1.00	—	—	5.00	—
	A4	1.00	2.00	—	1.00	—
	A5	1.00	3.00	—	1.00	—
	A6	.70	2.00	—	1.00	—

WELDING ALLOY AIR HARDENING - TYPE SYMBOL A

000THCUT						
D1	1.00	—	—	12.00	—	—
D2	1.50	—	—	12.00	—	1.00
D3	1.50	—	—	12.00	—	1.00
D4	2.25	—	—	12.00	—	—
D5	1.50	—	—	12.00	—	—
D6	2.25	—	1.00	12.00	—	1.00
D7	2.35	—	—	12.00	—	4.00

With smooth cutting free machining additives

*Almedie and Almedie Smoothcut contain approx V. 90%

COLUMBIA TOOL STEEL COMPANY • CHICAGO HEIGHTS, ILLINOIS

THE JOURNAL OF CLIMATE

ESTATE PLANNING AND WILLS - WHICH STATES IN THE UNITED STATES

Cincinnati 25	Cleveland 14	Detroit 3	Los Angeles 99	Milwaukee 19	St. Louis 13
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COLUMBIA TOOL STEELS

NEW **A** ELECTROPOLISHER FOR METALLOGRAPHIC SAMPLES



No. 1723 AB EXTRA TANK

No. 1720 AB ELECTROPOLISHER

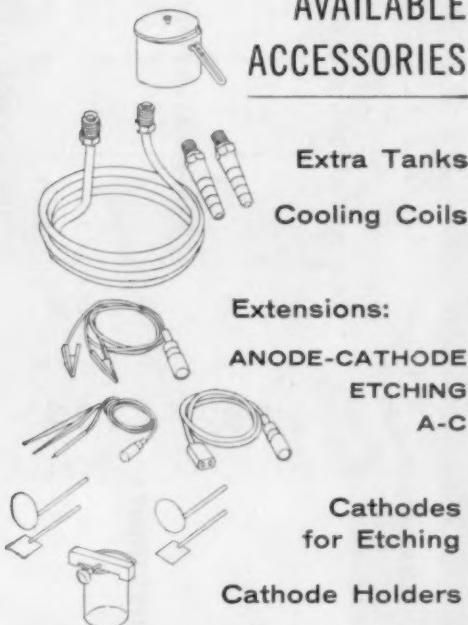
- SIMPLICITY IN OPERATION
- INTERCHANGEABLE ELECTROLYTE TANK
- IMPACT and CORROSION RESISTANCE
- EASY TO FILL and EMPTY
- CONVENIENT ELECTROLYTE STORAGE
- COMPLETE ELECTRICAL INSULATION
- INCREASED SAMPLE AREA
- GREATER ELECTROLYTE CAPACITY
- VERSATILE POWER SOURCE
- D. C. RIPPLE CONTROL
- FIELD TESTED and APPROVED
- REASONABLY PRICED



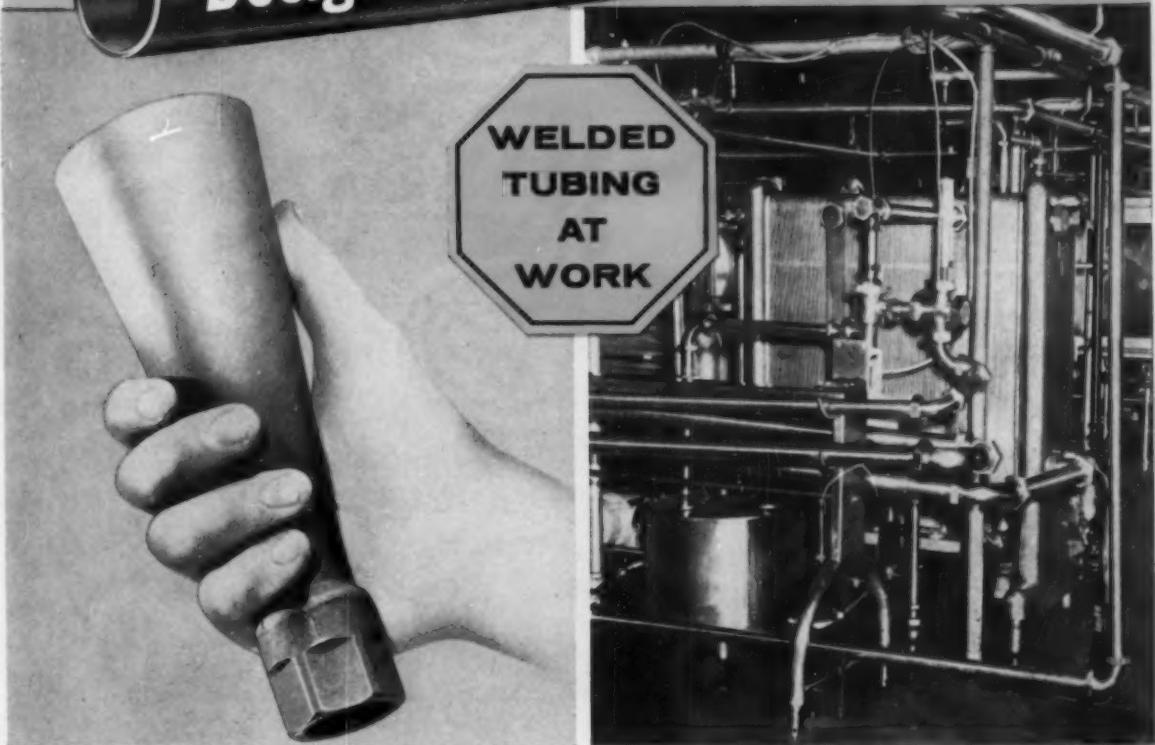
Buehler Ltd.

METALLURGICAL APPARATUS
2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

AVAILABLE ACCESSORIES



Design with TUBING in mind!



Once machined from solid bar stock, this machine gun flash hider was produced at a 92% saving in cost by forming from Welded Carbon Steel Tubing.

Positive sanitation, non-contaminating, non-corrosive, non-breakable—all these call for Welded Stainless Steel Tubing in hundreds of Pasteurizers like these and all sanitary services.

Reduce fabricating costs—Insure purity

CHOOSE WELDED STEEL TUBING

Carbon • Alloy • Stainless Steel

Easy workability, outstanding uniformity, wide range of grades make Welded Tubing applicable to nearly every use requiring a hollow part. Whether a mechanical component, a structural use, to convey liquids

or gases, or move at high RPM—there is a grade, size and shape of Welded Tubing that will do your job best. For all tubing applications, consult a quality tube producer.

Design inspiration for you

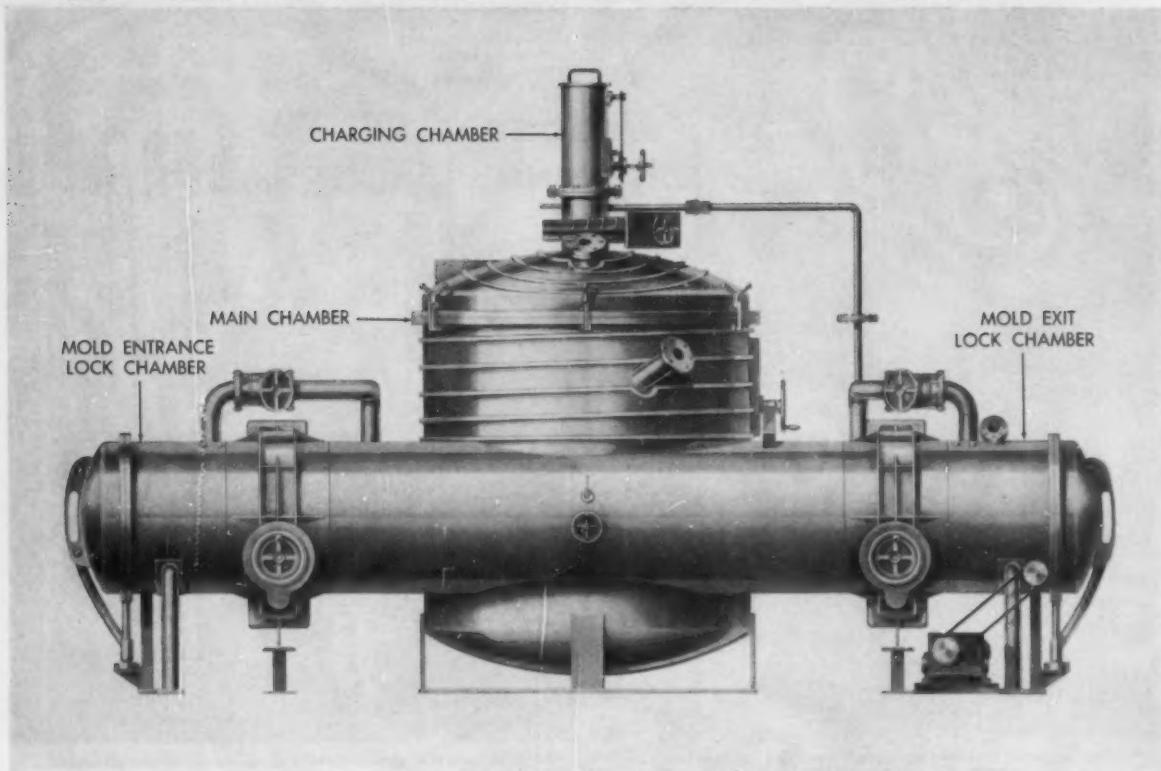
The 260-page Handbook of Welded Steel Tubing contains inspiration and data for tubing designs. For your copy, write on your company letterhead, giving your title.

FORMED STEEL TUBE INSTITUTE
850 HANNA BUILDING • CLEVELAND, OHIO

An Association
of Quality
Tube
Producers



VACUUM



The Vacuum Melting and Casting Furnace shown above, as exhibited in the KINNEY Booth at the combined Metals Show in Chicago. This pilot plant or small production unit, designed for continuous operation, will melt up to 300 lbs. of Steel . . . (Zirconium, 250 lbs., Uranium, 725 lbs. and Titanium, 165 lbs.), forming small ingots or direct shape castings under high vacuum or inert gas atmosphere. The unit has many interesting features and great versatility.

The KINNEY Melting and Casting Furnace is composed of four basic sections which function as separate Vacuum chambers: 1—THE REMOVABLE CHARGING CHAMBER; 2—THE MAIN VERTICAL FURNACE CHAMBER, which contains the induction melting coil and crucible assembly with external mechanism for tilt pouring; 3—THE MOLD ENTRANCE LOCK arranged for isolation from atmosphere or main chamber; 4—THE MOLD EXIT LOCK for delivering the finished piece without breaking vacuum. Thus, 3 operations may be performed

simultaneously—charging, melting and delivery of a finished mold.

Modifications for power requirements and vacuum pumping facilities to precisely meet a special need are readily effected. Chambers and mechanism for addition of separate alloys may be added.

Furnaces of the same general principle may be supplied for capacities of 2500 lbs., 5000 lbs. or more. In these larger furnaces, valves, hoists and crucible tilt mechanisms will be equipped with air operated motors for infinite speed control instead of manual operation as in the unit shown.

IN OPERATION AT THE SHOW

Twice each day, visitors to the KINNEY Booth were given the opportunity of seeing a Sintering Furnace in actual operation. The KINNEY F-15 Sintering Furnace shown at the Metals Show is capable of working at 2200° C.

FURNACES

by **Kinney**®

New Developments in High Vacuum Melting, Annealing, Brazing, Welding, Sintering, Stream Degassing and Heat Treating . . .

NEW HIGH TEMPERATURES

NEW HIGH VACUUM

NEW HIGH VOLUME

KINNEY engineering has taken a giant step, breaking through old limitations, to bring you High Vacuum Furnaces tailored to your needs—regardless of the metals with which you work. Their advanced design accents three advantages: 1—Low first cost and low operating cost; 2—Versatility to embrace a broad range of operations; 3—Important economies in time and power consumption.

KINNEY High Frequency or Resistance Heated Sintering Furnaces enable you to work at 2200° C . . . Clean Vacuum . . . No Carbon! Pumping Systems are designed for *high, clean* Vacuum; frequently employing Fractionating Diffusion Pumps and Cold Traps. Special Pumping Systems are available for materials with high out-

gassing rates. Units can be modified for Sintering in inert atmosphere.

KINNEY Furnaces and Heat Treating Chambers, now in service, are setting outstanding performance records in the production of high purity Titanium, Germanium, Zirconium, Uranium, Tantalum, Beryllium, Silicon, Molybdenum and the rare earth metals, as well as Stainless and High Alloy Steels and the more common metals.

From laboratory and pilot plant to full scale production, the Vacuum "Know-How" of KINNEY engineers is a definite plus factor for you. Write for information on the KINNEY High Vacuum Furnace to update your facilities.

WRITE—

FOR YOUR COPY OF THE
PROGRESS REPORT TO
THE METALS INDUSTRY
DESCRIBING KINNEY
VACUUM FURNACES

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY

3584L WASHINGTON STREET • BOSTON 30 • MASS.



Please send me copy of your latest bulletin describing new developments in Kinney High Vacuum Furnaces.

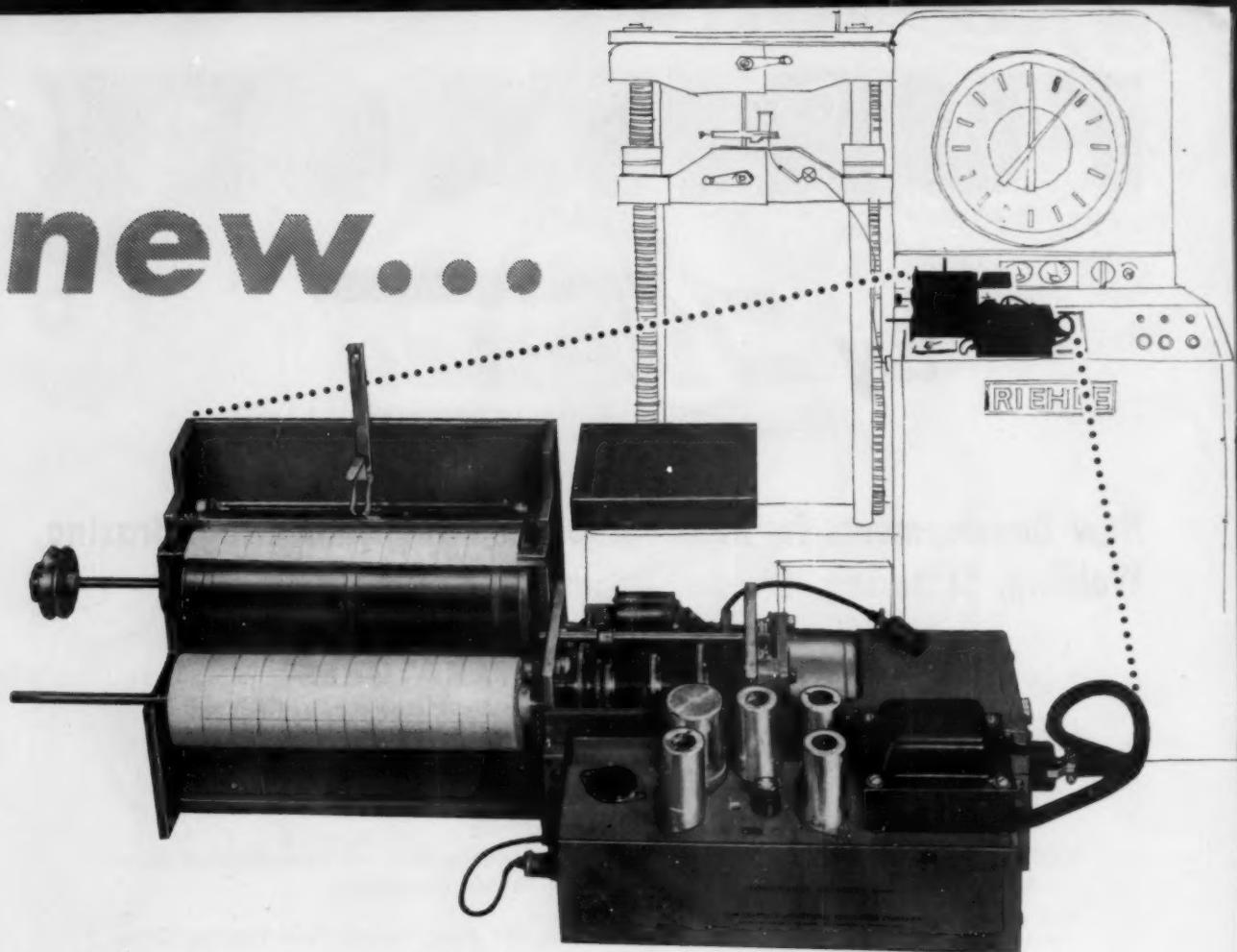
Name _____

Company _____

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City _____ Zone _____ State _____

new...

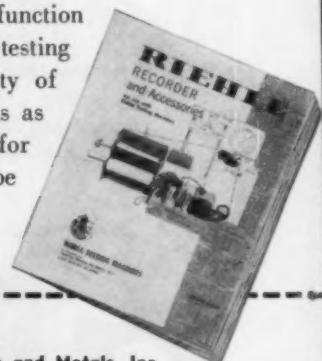


Built-in RIEHLE recorder... allows command post testing

See how the new recorder is built right into the Riehle indicating unit at a convenient location. That's why the operator can observe everything *from one spot* while a test is in progress. Without changing his position, he can watch the stress-strain curve . . . the load indicating dial . . . the strain and load rate indicators . . . and the test specimen. That's command-post testing!

Here is true convenience, because the Riehle recorder is expressly designed to function as an integral part of the Riehle testing machine. And a complete variety of Riehle strain follower instruments as well as special instrumentation for elevated temperature testing can be accommodated.

Free Bulletin . . . Mail Coupon



RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-1157, East Moline, Illinois

Please send your big new Bulletin with full data on the Riehle Model RD-5 Recorder and special instrumentation.

COMPANY _____

ADDRESS _____

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ATTENTION MR. _____

Riehle TESTING MACHINES
A DIVISION OF
American Machine and Metals, Inc.
EAST MOline, ILLINOIS

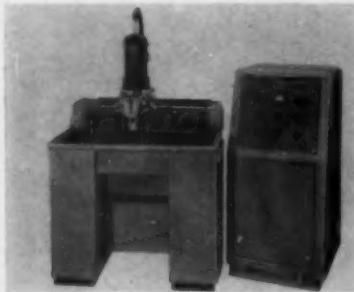
"One test is worth a thousand expert opinions"

APPLICATION and EQUIPMENT

new products

X-Ray Microscope

A new projection microradiograph has been announced by the Instruments Div., Philips Electronics, Inc. The unit employs an X-ray source approximately one micron in size to produce enlarged images of specimens placed close to the radiating surface. Contrast is controlled to some extent by varying the accelerating potential of the electron beam and by changing target materials. The electron-optical system includes an electron gun, high-voltage source for electron acceleration.



tion, electro-magnetic lenses to control beam size and configuration, and targets having surface planes normal to the beam at the end of its path. Images are observed on a viewing screen and are recorded with a camera that accommodates five exposures on a 2 by 10 in. plate. Exposure time is approximately 1 min. at 10 to 12 kv. Resolution is 1.0 micron or better at 2 to 20 kv. Direct magnifications up to 70 \times are possible on the photographic plate and up to 250 \times on the viewing screen-binocular combination. Total useful photographic enlargement is 1500 \times .

For further information circle No. 1340 on literature request card, page 48-B.

Tubing

A new line of conduit and electrical tubing made of Yoloy, nickel-copper, openhearth steel, has been announced by Youngstown Sheet and Tube Co. Soil corrosion studies covering 14 years in 13 different soils show Yoloy pipe has 19% less pitting and 36% less loss of weight than carbon

steel pipe, and 10% less pitting and 28% less loss of weight than wrought iron pipe.

For further information circle No. 1341 on literature request card, page 48-B.

Laboratory Furnace

R. Y. Ferner Co. has announced a Chevenard-Joumier laboratory furnace. It is a cylindrical bench-type unit which is automatically controlled to maintain a selected temperature or follow a pre-selected program heating cycle. Two types are available—one with a range to 1922° F., the other to 2372° F.

For further information circle No. 1342 on literature request card, page 48-B.

Aluminizing

A new control and heating station for preheating and diffusing automotive valves during aluminizing operations has been announced by Lindberg Engineering Co. The unit consists of a motor generator, a control station for regulating and controlling the application of high-frequency power and two heating stations. A vertical conveyor system wrapped around the 14-ft. high cabinet moves



the valves through the various operations and is loaded and unloaded automatically from the shop overhead conveyor. A metallizing gun with

separate control panel sprays the valves with molten aluminum which in the subsequent heating operation forms an iron-aluminum alloy.

For further information circle No. 1343 on literature request card, page 48-B.

Sawing Graphite

National Carbon Co. has announced a band saw which will slice a 2-in. slab of graphite from a cylinder 45 in.



in diameter to an accuracy of $\pm 1/16$ in. It can cut material as thick as 49 in. and has a maximum table travel of 11 ft. A special blade is used to give the tolerances required. The plates being sawed in the illustration from a piece of graphite 35 by 110 in. will later be used for reference forms for the brazing of stainless steel honeycomb aircraft panels.

For further information circle No. 1344 on literature request card, page 48-B.

Pressure Chamber

A test unit that provides pressures to 30,000 atmospheres in a chamber $\frac{1}{4}$ in. in diameter by 10 in. high has been announced by Nucor Research, Inc. Pressure is obtained by means of a $3\frac{1}{2}$ in. diameter piston which is actuated by oil from a pump and which, in turn, actuates a $\frac{1}{2}$ -in. diameter piston in the top of the pressure chamber. The pressure chamber is inside a tube that has an external taper. As the chamber is brought up to pressure, a piston at the bottom of the Parabar is operated to force the chamber tube upward into a surrounding taper in a stack of heavy steel rings, thus applying a squeeze that prevents radial expansion of the chamber. Electrically-insulated leads

IN CUTLERY, TOO.

Sharonsteel Quality

STANDS OUT

"Cutlery manufacturers know well the name SHARON, for in the past five decades SHARON has excelled in the production of steels used in the manufacture of implements for cutting."

From exquisite carving blades to rugged chain saw teeth, razor sharp scalpels, agricultural and earth moving equipment SHARON provides the edge holding and abrasion resistant steels manufacturers can trust.

If you make products that require cutting edges that endure we suggest that you contact the SHARON representative nearest you and take advantage of this vast library of experience.



SOMEROFF, N.Y.

SHARONSTEEL

For 56 Years
a Quality Name
in Steel

174
SHARON STEEL CORPORATION, SHARON, PENNA.

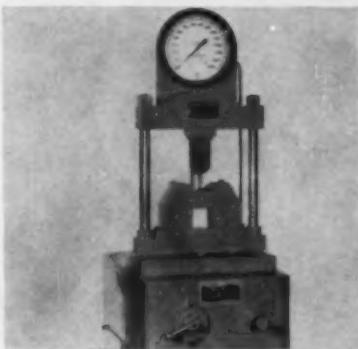
CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, SEATTLE, MONTREAL, TORONTO

may be conducted into the pressure chamber to permit measuring various phenomena.

For further information circle No. 1345 on literature request card, page 48-B.

Bend Tester

Steel City Testing Machines has announced a new guided bend testing machine designed to test butt-welded samples. The machine has its own hydraulic load-applying means. Different fixtures for different thicknesses of metal can be interchanged.



When testing a given thickness there is no need to remove any of the fixtures between tests, thereby keeping dies in perfect alignment. As the lower die retracts at the conclusion of a test, an ejection device operates to remove the specimen from the lower die. Operator can pick it out with his hands after the machine has completed its cycle. The tester is 70 in. high, occupies a floor space of approximately 18 by 24 in., has a 15,000 lb. capacity and employs a $\frac{1}{2}$ -h.p. motor. For further information circle No. 1346 on literature request card, page 48-B.

Gas Analysis

A new gas analyzer which measures traces of hydrogen, oxygen and nitrogen in metals has been announced by Fisher Scientific. It is being used to determine gases in titanium, nickel, manganese, niobium, vanadium, zir-



conium and steel. The vacuum fusion furnace and extraction tube are interchangeable and connected to the analytical train through a cold trap and ball-and-socket joint. Vacuum fusion analysis takes 10 to 20 min., hydrogen separation 30 sec. An auxiliary oxygen analyzer may be connected to the train.

For further information circle No. 1347 on literature request card, page 48-B.

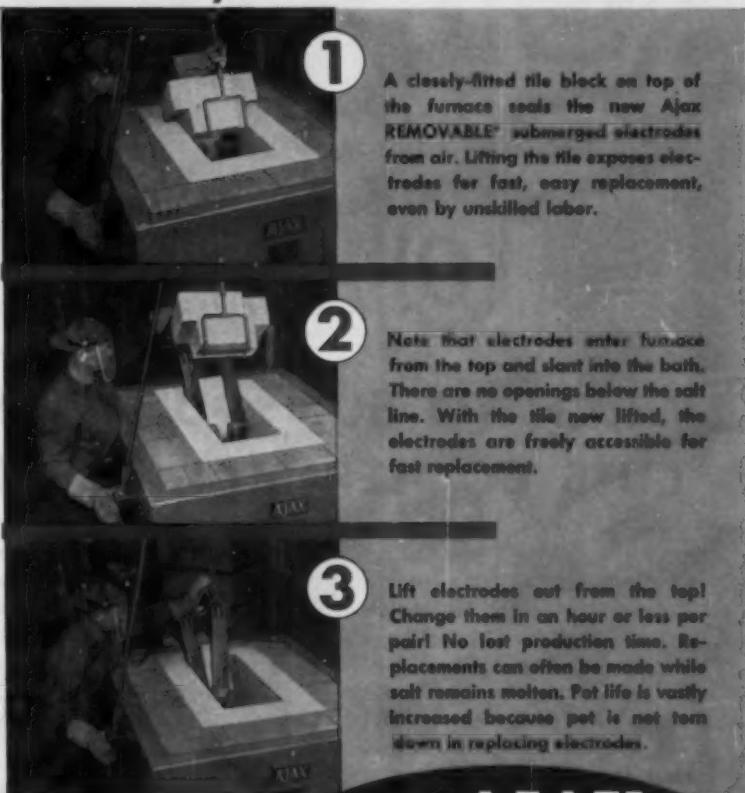
Spectroanalysis

Intercontinental Electronics Corp. has announced the automatic Spectro-

Lecteur, a direct reading spectrographic analyzer which permits measurement of instantaneous values and therefore direct reading of analysis results without resorting to integration. The automatic Spectro-Lecteur includes two photomultipliers; one views the line of the basic metal in the alloy, and the other travels automatically along the focal plane of the spectrum to detect the radiations from the line of each element in turn, according to a pre-arranged program. The output of the two photomultipliers is fed to two identical amplification

CHANGING AJAX SUBMERGED ELECTRODES IS

easy as 1-2-3!



1 A closely-fitted tile block on top of the furnace seals the new Ajax REMOVABLE[®] submerged electrodes from air. Lifting the tile exposes electrodes for fast, easy replacement, even by unskilled labor.

2 Note that electrodes enter furnace from the top and slant into the bath. There are no openings below the salt line. With the tile now lifted, the electrodes are freely accessible for fast replacement.

3 Lift electrodes out from the top! Change them in an hour or less per pair! No lost production time. Replacements can often be made while salt remains molten. Pot life is vastly increased because pot is not torn down in replacing electrodes.

* Although made of non-critical metals, life of Ajax Removable Submerged Electrodes is superior to that of nickel alloy electrodes of conventional design.

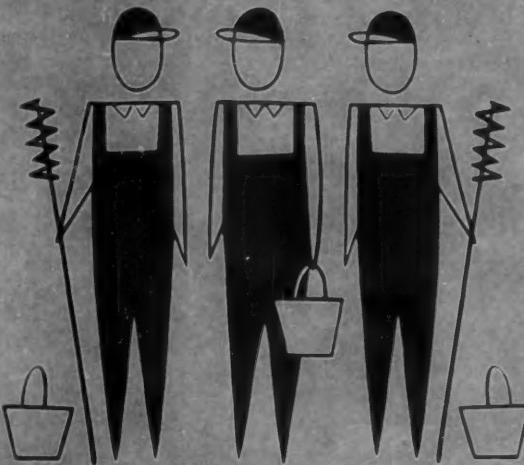
Write for Bulletin 810



AJAX ELECTRIC COMPANY
910 Frankford Ave.
Associates: Ajax Engineering Corp., Ajax Electrothermic Corp.

Pioneering Salt Bath Progress

BEFORE



3 MEN 8 HOURS
PER WEEK

AFTER



1 MAN 6 HOURS
PER MONTH

A switch to Sun Quenching Oil Light resulted in this dramatic reduction in cooler-maintenance man-hours in a major automotive plant.

SWITCH TO SUN QUENCHING OIL LIGHT CUTS COOLER MAINTENANCE BY 94%

After switching to Sun Quenching Oil Light, a leading auto manufacturer reported a *94% reduction in cooler maintenance*. No heavy sludge deposit had formed on cooler coils after 18 months of continuous use. It took *fewer men far less time* to clean coolers.

Reason: Sun Quenching Oil Light has natural detergency and solvent action that *keeps cooling systems clean for long periods*.

It's Versatile. Sun Quenching Oil Light can be used in any type of quenching-oil system. It has uniform quenching properties and low drag-out.

It's Economical. Sun Quenching Oil Light can save you money two ways . . . in low initial cost and in reduced maintenance.

For Full Information, call your Sun representative or write to **SUN OIL COMPANY**, Philadelphia 3, Pa. Dept. MP-11.



INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY PHILADELPHIA 3, PA.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL

METAL PROGRESS

channels. Each channel comprises a preamplifier (containing input filters and load resistors), a main amplifier, a band filter, a rectifier, a time con-



stant network and a milliammeter for direct reading of the output. The outputs of the two channels are fed to a chart recorder that marks the instantaneous value of their ratio on a graph.

For further information circle No. 1348 on literature request card, page 48-B.

Laboratory Mill

Loma Machine Mfg. Co. displayed an 8-in. wide 2-high/4-high combination rolling mill at the National Metal



Show in Chicago, November 4 to 8. This machine offers facilities for hot and cold rolling of flat or shaped products in one machine.

For further information circle No. 1349 on literature request card, page 48-B.

Salt Bath Pump

A new high-temperature pump for handling molten salt and other hot liquids up to 2000° F. has been announced by Ajax Electric Co. The pump is fabricated of a limited number of heat resisting alloy parts. Using an air supply of 90 psi, the pump can handle 600 lb. of molten salt a minute; with a 60 psi. supply, 450 lb. a minute. For further information circle No. 1350 on literature request card, page 48-B.

Chromalloy-Stainless Sheet

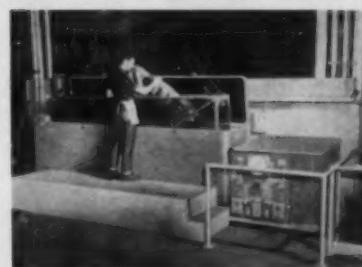
Chromalloy Corp. has announced a chromalloy-stainless sheet which can replace Type 430 in some applications. The core of this sheet is SAE 1010 annealed steel. Through high temperature diffusion of chromium into the 1010 steel, a stainless surface is formed. It is integral with the base

metal and cannot be separated from it. The sheet can be bent and formed, staked, drawn or welded. It withstands operating temperatures of 1200° F. indefinitely and 1500° F. for hundreds of hours. At present it is produced in sizes up to 2 by 5 ft. and gages 16 to 24.

For further information circle No. 1351 on literature request card, page 48-B.

Cold Treatment

A freezer for the stabilization of austenitic stainless steels and tool steels has been announced by Cincinnati Sub-Zero Products. Model 3SR



120-47 has a 47 cu. ft. chamber and a net thermal capacity of approximately 6000 Btu. per hr. at -120° F. Using convection fluid, it will chill 250 lb. of steel per hr. from ambient to -120° F. For faster and more uniform chilling, the chamber is equipped with convection fluid agitator.

For further information circle No. 1352 on literature request card, page 48-B.

Optical Pyrometer

An optical pyrometer with a high-temperature range to 7600° F. has been announced by Leeds & Northrup Co. The instrument can be used for



such applications as vacuum melting, manufacture of cermets, in research and in jet-engine component tests.

For further information circle No. 1353 on literature request card, page 48-B.

Welding Flux

Ampco Metal, Inc., has announced a new welding flux which is suitable for general brazing, cast-iron welding and cast-iron brazing with the oxy-acetylene process. Ampco-Braz flux No. 2 has good wettability, is non-

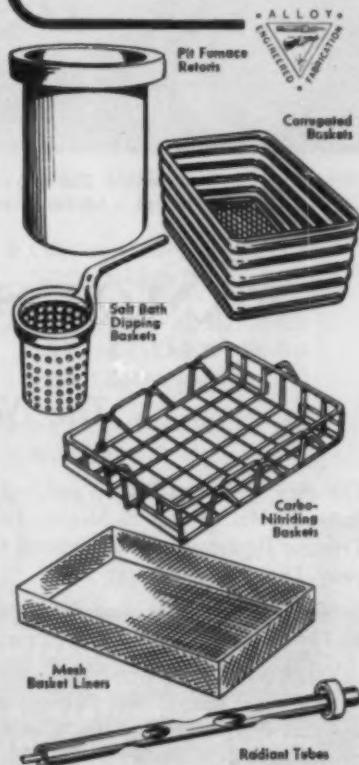
NOW Available . . .

MISCO Heat-Treating Tools from Stock!

MISCO heat-treat process equipment is engineered and fabricated by qualified specialists in the field of heat-resisting alloy materials.

With a wide variety of job-proven heat-resisting steel products available for immediate delivery, Misco Fabricators provide a real service to heat-treaters, who no longer need carry an expensive inventory of equipment.

Remember, whatever your need, Misco Fabricators offer sound, economical designs in the best metal for your purpose. It pays to do business with Misco Fabricators—Specialists in Nickel-Bearing Alloy Fabrication.

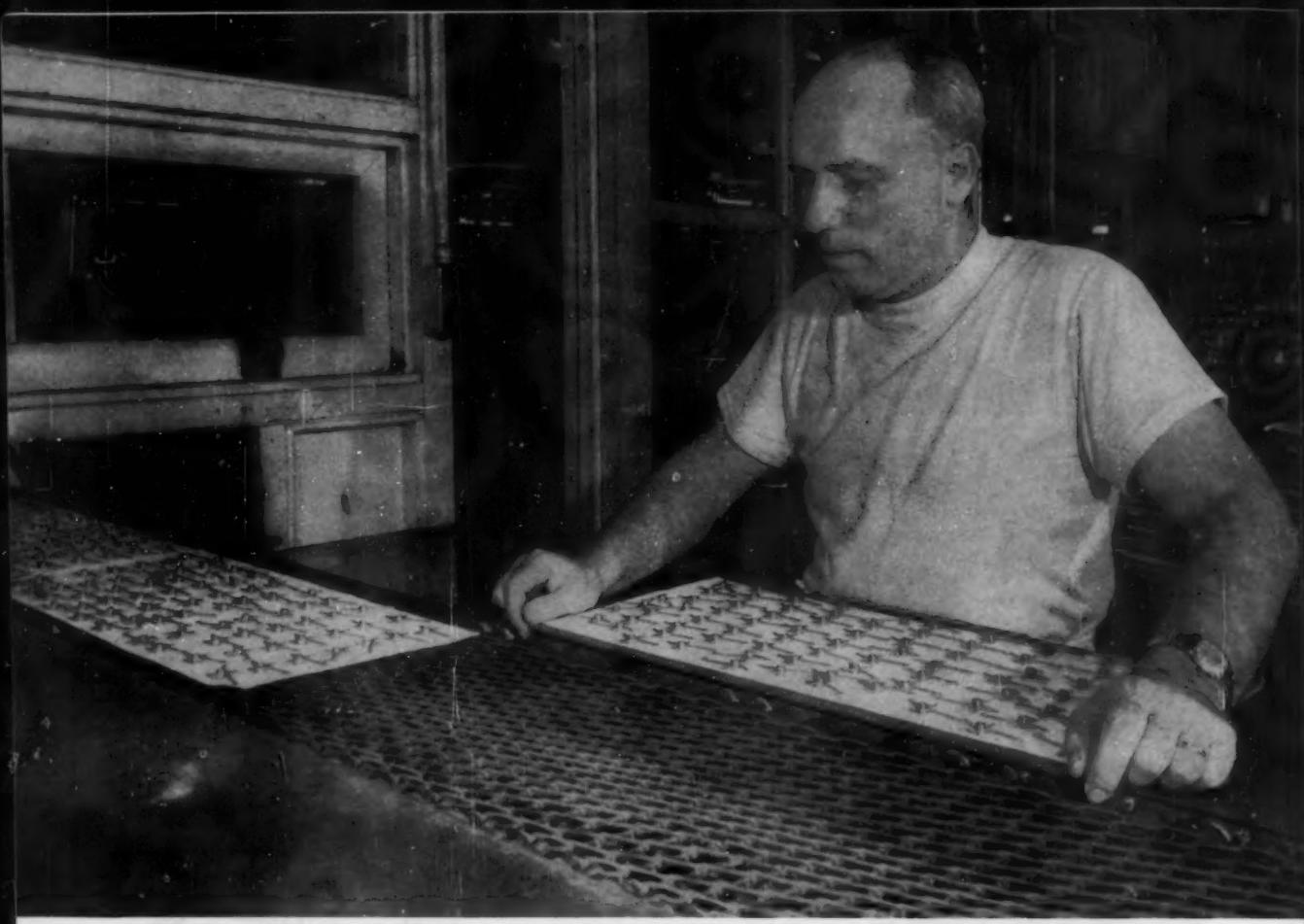


Special Equipment Designed and Made to Order

MISCO FABRICATORS, INC.

Designers, Builders, Fabricators of Heat-Resisting Alloy and Stainless Steel Equipment
2420 WILLS AVENUE • MARYSVILLE, MICHIGAN

TELEPHONE YUKON 5-8191



At National Cash Register, Wissco Belts carry small parts for accounting machines and cash registers through a brazing furnace at 2070° F. Belts are in operation 24 hours a day, 7 days a week.

FAMOUS NAMES ride on WISSCO BELTS

The National Cash Register Company

The story of Wissco Belts is best told by their users. For instance, Mr. Charles E. Mentel, Foreman of the Heat Treating Department, The National Cash Register Company, Dayton, Ohio, says:

"Our Wissco Belts last from 20% to 25% longer, and require less down time to remove slack."

These belts are used in a high temperature operation for copper brazing 3,000 different accounting machine and cash register parts. "The Wissco Belts pass through the furnaces 24 hours a day, 7 days a week," Mr. Mentel explains. "They are alternately subjected to a temperature of 2070° F. within the furnace and room temperature outside, the complete heating cycle taking 7 to 20 minutes. This continuous heating causes a definite stretch to develop in the belts; to take up slack we remove a section of the belt. Wissco Belts last from 4 to 6 months before we find it necessary to replace them, during which time they are cut about three times. The belts we used formerly

lasted from 3 to 5 months and sections usually had to be cut out at least six times before replacement."

"Our Wissco Belts have withstood the extreme changes of temperature, retaining their original shape with a minimum of distortion," Mr. Mentel adds. "We have been using them since 1933."

Longer service life...less down time...more economical performance under adverse conditions—important cost-cutting factors in any conveying or processing operation.

5432

WISSCO BELTS
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION



THE COLORADO FUEL AND IRON CORPORATION • Denver and Oakland
WICKWIRE SPENCER STEEL DIVISION • Atlanta • Boston • Buffalo • Chicago • Detroit
New Orleans • New York • Philadelphia • CF&I OFFICES IN CANADA: Montreal • Toronto

fuming and nontoxic, depresses filler metal bubbling and fuming and has deep penetration.

For further information circle No. 1355 on literature request card, page 48-B.

Spring Tester

A new tester for checking loads and deflections of compression and extension springs has been announced by Carlson Co. Loads are shown on the large 15 in. dial by turning a handwheel; lengths are indicated on stainless steel rules in fractions of an inch and in decimals. Loads of $\frac{1}{2}$ to 300 lb., spring diameters up to $4\frac{1}{2}$ in., spring lengths of $\frac{1}{4}$ to 12 in. can be accommodated. A dial indicator can be applied to register deflections in thousandths of an inch.

For further information circle No. 1355 on literature request card, page 48-B.



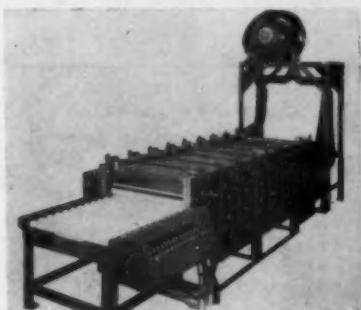
Flow Meters

A new line of dual-range flow meters has been announced by Air Reduction Sales Co. They are designed for inert-gas welding, flushing molten metals, laboratory service and other industrial applications. Switching from either flow range to the other is done by means of a piston-type selector valve. Flow rate within either range is controlled by a sensitive needle valve. The series includes seven direct-reading flow meters, each for a specific gas, and one general-purpose flow meter, provided with calibration curves, which will meter any of five gases. A combination of two or more flow meters can be used to proportion a mixture of gases.

For further information circle No. 1355 on literature request card, page 48-B.

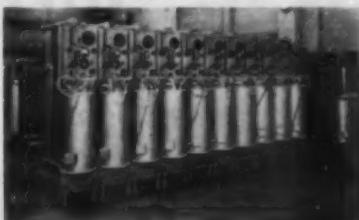
Sheet Cleaning

Industrial scrubbing machines designed to clean both the top and bot-



tom surfaces of flat stock metal plates of oil, grit, and surface accumulations, have been announced by the Machine Div. of the Fuller Brush Co. The longer machine for cleaning extra heavy accumulations of surface dirt, is equipped with eight sets of brushes, six for scrubbing and two for rinsing away residual detergent solution, and will process sheets at a rate of 100 ft. per min. The shorter model has three sets of brushes, two for scrubbing and one for rinsing, and cleans flat metal plates at a rate of 60 ft. per min. Both have a maximum width capacity of 38 in. A detergent and water solution is pumped onto the plates as they are conveyed through the machine by means of feed rolls. They are then scrubbed and scrub-

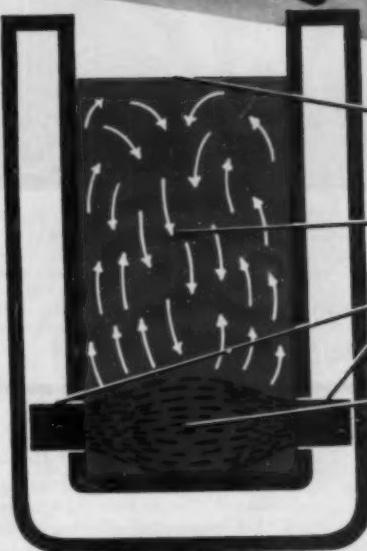
rinsed. The plates then pass through an air-squeegee and come out dry. For further information circle No. 1357 on literature request card, page 48-B.



Creep Testing

A new 12,000 lb. creep rupture testing machine has been announced by Tatnall Measuring Systems Co. It has an 1800° F. split furnace, sealed

Making Sense...



- MAXIMUM WORK SPACE WITH MINIMUM BATH AREA.
- CIRCULATION - CONVECTION CURRENTS.
- ELECTRODES POSITIONED TO GIVE CLEAR WORKING AND CLEANING AREA.
- HEAT INTRODUCED AT BOTTOM.
- ANY DEPTH.

... Makes the Difference in —

ALUMINUM BRAZING • HI SPEED STEEL HARDENING • NEUTRAL HEATING • BILLET HEATING • ANNEALING • CARBURIZING MARTEMPERING • AUSTEMPERING

Batch and Full Automation

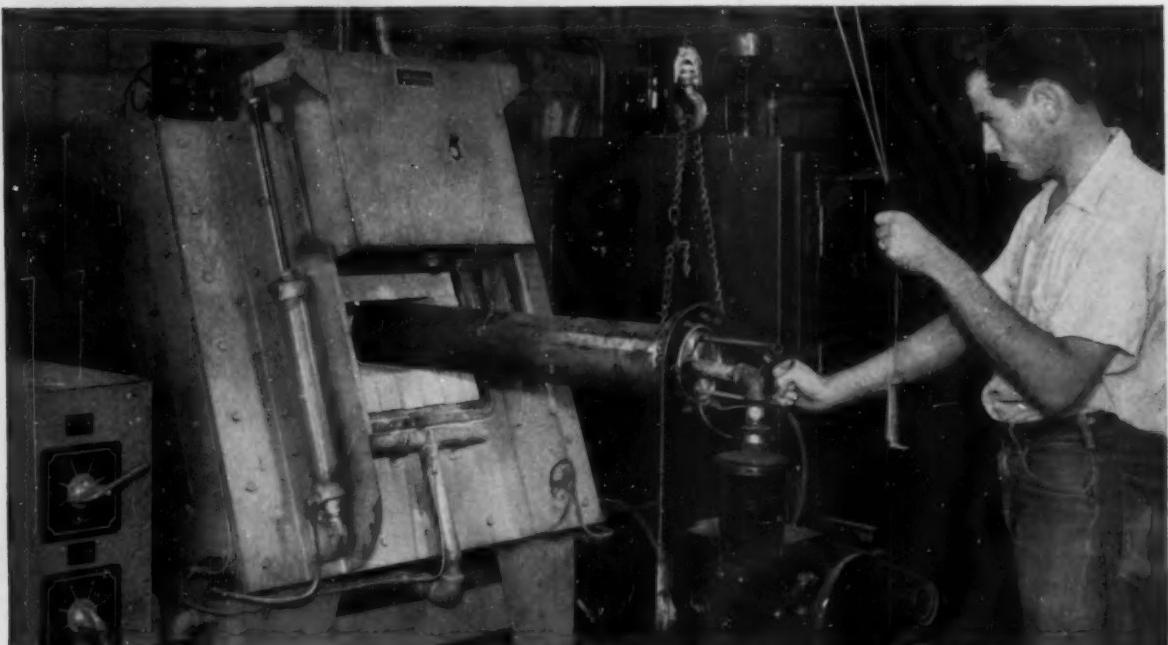
PTON ELECTRIC FURNACE COMPANY
30435 Greenbeck • Roseville, Michigan

CANEFCO, LTD., TORONTO, ONTARIO, CANADA
ELECTRIC RESISTANCE FURNACE CO., LTD., WEYBRIDGE, ENGLAND

Electric furnace users and builders report:

"HOT RODS" PAY OFF!

Progressive firms list advantages of CRYSTOLON* heating elements



Metallurgical Consultants, Inc., of Los Angeles say that "Hot Rods" provide excellent service life for a variety of heat treating applications including vacuum and protective atmosphere work. Their furnace, shown above, is used for heat treating a wide variety of parts. This requires several daily temperature variations, from 1600°F. to 2300°F., causing repeated thermal shocks to the heating elements. Yet the original "Hot Rods" — Norton heating elements — show no signs of failure after

more than two years of this especially hard service.

The builders of this furnace, the Pacific Scientific Company of Los Angeles, Calif., are equally enthusiastic. They report that the long and better operating service of "Hot Rods" more than justifies their use in any electric furnace requiring non-metallic heating elements. As a result, they install these Norton CRYSTOLON heating elements in every furnace of this type they build.



Norton CRYSTOLON Heating Elements, or "Hot Rods," are a typical Norton Rx — an expertly engineered refractory prescription for greater efficiency and economy in electric kiln and furnace operations. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

Many plants report that Norton heating elements outlast other non-metallic elements *up to 3 to 1!* This much longer life means savings in element costs, because fewer elements are needed. Also, you get reduced maintenance, due to less changing of elements or voltage taps. And "Hot Rods" help protect product quality because their slow, evenly matched rate of resistance increase means more uniform heating.

The big, illustrated booklet, *Norton Heating Elements*, gives further facts on how "Hot Rods" can help improve your furnace operations and cut costs. Write for your copy to NORTON COMPANY, Refractories Division, 330 New Bond Street, Worcester 6, Massachusetts.

NORTON
REFRACTORIES
Engineered... Rx... Prescribed

*Making better products...
to make your products better*

NORTON PRODUCTS:
Abrasives • Grinding Wheels
Grinding Machines • Refractories
BEHR-MANNING PRODUCTS:
Coated Abrasives • Sharpening Stones
Ball-cut Tapes

*Trade-Mark Reg. U.S. Pat. Off. and Foreign Countries

at the bottom to prevent stack effect. It has three heating elements with shunts to provide uniform temperature along the gage length. A bank of these machines coupled with a single dead-weight load maintainer makes it possible to get a large number of machines in a limited floor space. The lever arm is eliminated and the force is applied directly to the specimen. For further information circle No. 1358 on literature request card, page 48-B.

Ultrasonic Processing

The General Ultrasonics Co. has announced new 5-gal. and 8-gal. tanks for ultrasonic cleaning, degreasing, pickling and electroplating. These new Sonitanks operate at a resonant frequency of 20 kc. per sec. Reinforced



transducer elements are attached by riveting. The treatment chambers are made of Type 302 stainless steel with input and output drains to allow for recirculation and filtering of the liquid medium. The 5-gal. tank operates with a 400 watt, 20 kc. ultrasonic generator, the 8-gal. tank with a 700 watt, 20 kc. generator.

For further information circle No. 1359 on literature request card, page 48-B.

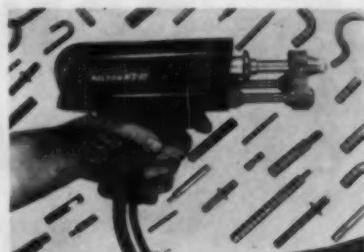
Sulphur Determinator

A new automatic sulphur determinator for sulphur titrations has been announced by Lindberg Engineering Co. The titration is accomplished by the addition of a proper titrant to the test solution until there occurs a condition called an end point, which is determined photoelectrically.



When the initial color intensity of the test solution is attained, the flow of titrant is shut off and a signal light indicates the end of the titration.

For further information circle No. 1360 on literature request card, page 48-B.



Welding

A new stud welding gun has been announced by the Nelson Stud Welding Div., Gregory Industries, Inc. The plastic gun weighs less than 4 lb. and is 9 in. long, but will weld studs up through $\frac{1}{2}$ in. in diameter. For further information circle No. 1361 on literature request card, page 48-B.

Low-Temperature Cabinet

Revo, Inc., has announced an industrial low-temperature freezer capable of reaching temperatures to -150° F. The new model has a storage capacity



of 6.5 cu. ft. in outside dimensions of 60 by 28 by 42 $\frac{1}{2}$ in. It is refrigerated by sealed hermetic compressors.

For further information circle No. 1362 on literature request card, page 48-B.

Zinc Brightener

R. O. Hull & Co. has announced a new 503 zinc brightener for still and automatic plating. It is a balanced liquid formulation which is added to the plating solution. It resists break-down at high temperature, a gallon lasting for 50,000 or more amp.-hr. It brightens deep recesses as well as surfaces and produces a fine grain.

For further information circle No. 1363 on literature request card, page 48-B.

Laboratory Furnace

Brinkmann Instruments, Inc., has announced a new laboratory muffle

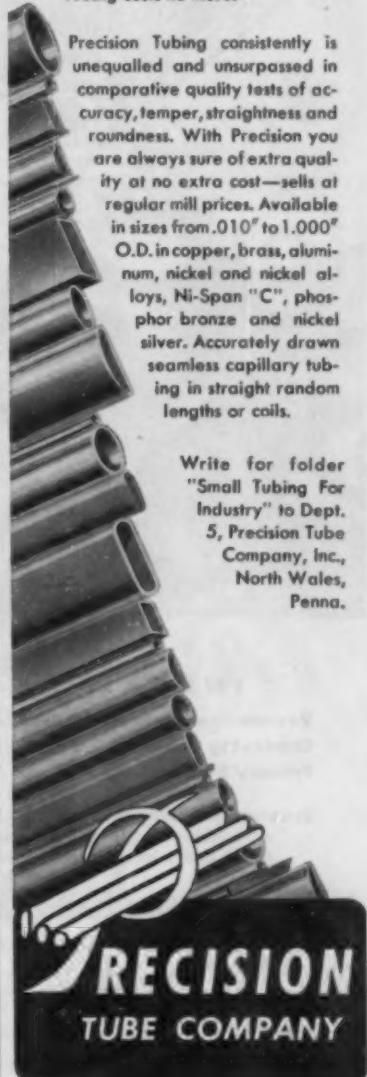
COMPARATIVE TESTS PROVE PRECISION TUBE

TOPS 'EM ALL IN QUALITY

One of America's most progressive manufacturers of refrigeration and air conditioning equipment constantly conducts quality tests of all materials purchased. Of the five leading suppliers of copper tubing their tests proved only Precision Tubing was rated "Excellent" in all specification requirements... yet Precision Tubing costs no more.

Precision Tubing consistently is unequalled and unsurpassed in comparative quality tests of accuracy, temper, straightness and roundness. With Precision you are always sure of extra quality at no extra cost—sells at regular mill prices. Available in sizes from .010" to 1.000" O.D. in copper, brass, aluminum, nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver. Accurately drawn seamless capillary tubing in straight random lengths or coils.

Write for folder
"Small Tubing For
Industry" to Dept.
5, Precision Tube
Company, Inc.,
North Wales,
Penns.

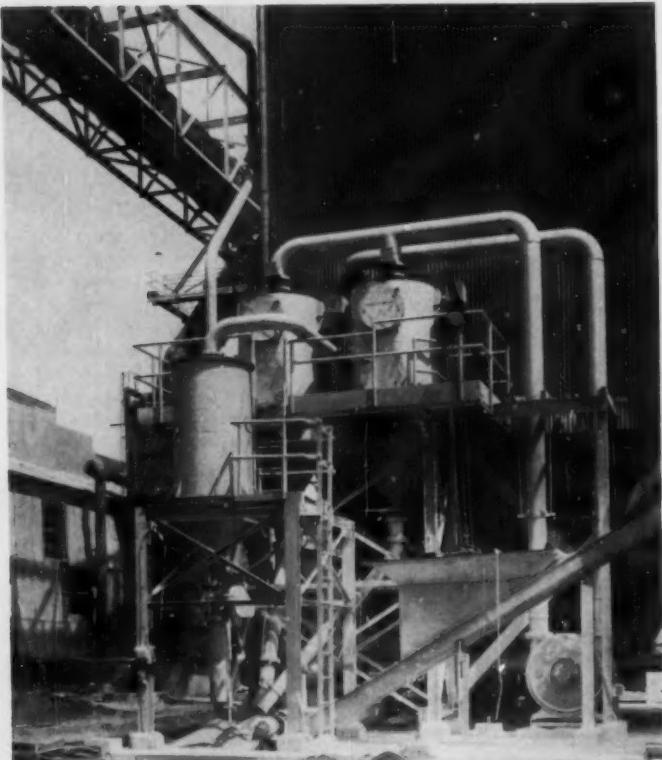


SPENCER VACUUM SYSTEM

handles both

**CONVEYING
and
CLEANING**

... at this Metals Plant



INSTALLATION DATA

Vacuum Producer: 60 H.P. Spencer.

Conveying Capacity: 7½ Tons per hour.

Primary Separator (1): 42" with 8" motor-driven rotary discharge valve.

Secondary Separators (2): 50" bag type with motor-driven bag shakers, automatic sequence timers and solenoid-operated valves.

A single SPENCER vacuum system handles two big jobs—pneumatic conveying and cleaning—at this modern metals plant.

Pneumatic Conveying of lead, zinc and copper dust is quick, dust-free and economical. Heavy material which settles out in breeching connecting the smelter to the Cottrell drops into hoppers. Once a day these hoppers are emptied by opening a slide gate valve. The accumulated heavy dust drops into a 6" Spencer vacuum line and is whisked away. Material thus recovered is returned to the smelter and melted over again—effecting an important saving for the company.

Cleaning, carried on whenever system is not being used for conveying, is done with standard 1 ¾" and 2" Spencer hose and tool equipment. The positive, dust-free sanitation that this bonus use of vacuum makes possible does more than assure plant cleanliness. It also guards the health of all employees.

Whatever your need in vacuum systems . . . for pneumatic conveying, cleaning, or both . . . it will pay you to check with SPENCER—leader in developing systems to meet individual needs.

Request these informative Bulletins:

No. 143-B Spencer Pneumatic Conveying

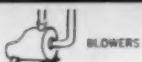
No. 155-B Spencer Vacuum



The **SPENCER**
TURBINE COMPANY
HARTFORD 6, CONNECTICUT



PORTABLE
VACUUM
CLEANERS



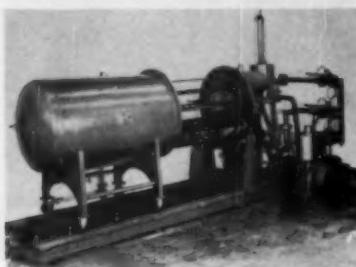
BLOWERS

furnace for temperatures to 3200° F. This furnace employs neither protective atmosphere nor vacuum. The heating element of pure rhodium is wound around a tube of sintered impervious recrystallized aluminum oxide. The heating zone is then embedded in refractory ceramic which is surrounded by a sheet-steel housing. The furnace is available in 3 sizes, and uses single phase a.c. current at 220/230 volts.

For further information circle No. 1364 on literature request card, page 48-B.

Vacuum Metallizing

A new vacuum metallizing unit has been announced by NRC Equipment Corp. The model 3148 coating unit is useful where the volume of work is insufficient to utilize the capacity of



a large production coater. The new unit has a 5-ft. long, 42-in. diameter horizontal coating chamber which provides 12,000 sq. in. of coating capacity per load. Two filament rods and a planetary jig which accommodates four work holding rods are cantilevered from the one head of the chamber which remains stationary.

For further information circle No. 1365 on literature request card, page 48-B.

Recorder

A new electronic Dynamaster X-Y recorder has been announced by the Bristol Co. The new strip-chart recorder will automatically plot a con-



tinuous curve showing the relationship of one measured variable to another. The instrument will plot temperature versus pressure or other variables. The Dynamaster records on a 12-in. strip chart and is available in pen speeds up to 0.4 sec. for full

scale traverse. Standard accuracy is 0.25%.

For further information circle No. 1366 on literature request card, page 48-B.

Steam Cleaner

A new steam cleaning machine has been announced by Circlo Equipment Co. A full operating pressure is generated within 90 sec. The entire sys-



tem is protected from excessive pressures at three independent points. The machine is available in stationary or portable models of 120 gal. capacity. The portable units are mounted on a free-rolling carriage.

For further information circle No. 1367 on literature request card, page 48-B.

Strain Cages

New SR-4 foil-type rosette strain gages have been announced by the Electronics and Instrumentation Div. of Baldwin-Lima-Hamilton Corp. The new rosettes have a sensitivity that is 8% higher than that of any previous rosettes. They need no lateral corrections except in the most precise testing problems, can withstand temperatures as high as 300° F. in continuous service and are thinner, more flexible and more easily applied than bonded wire SR-4 strain gages. Two sizes of bakelite bonded rosettes are available with gage lengths of $\frac{1}{2}$ and $\frac{3}{4}$ in. For further information circle No. 1368 on literature request card, page 48-B.

Cleaner

A new solvent that cleans, degreases and rustproofs all metal surfaces in one operation has been announced by Harry Miller Corp. Immunol is mixed with hot or cold tap water, a few ounces of the solvent to a gallon of water. It cleans by floating oil or foreign matter away. It is neutral, nontoxic and nonflammable, and can be applied by wiping, dipping or spraying.

For further information circle No. 1369 on literature request card, page 48-B.

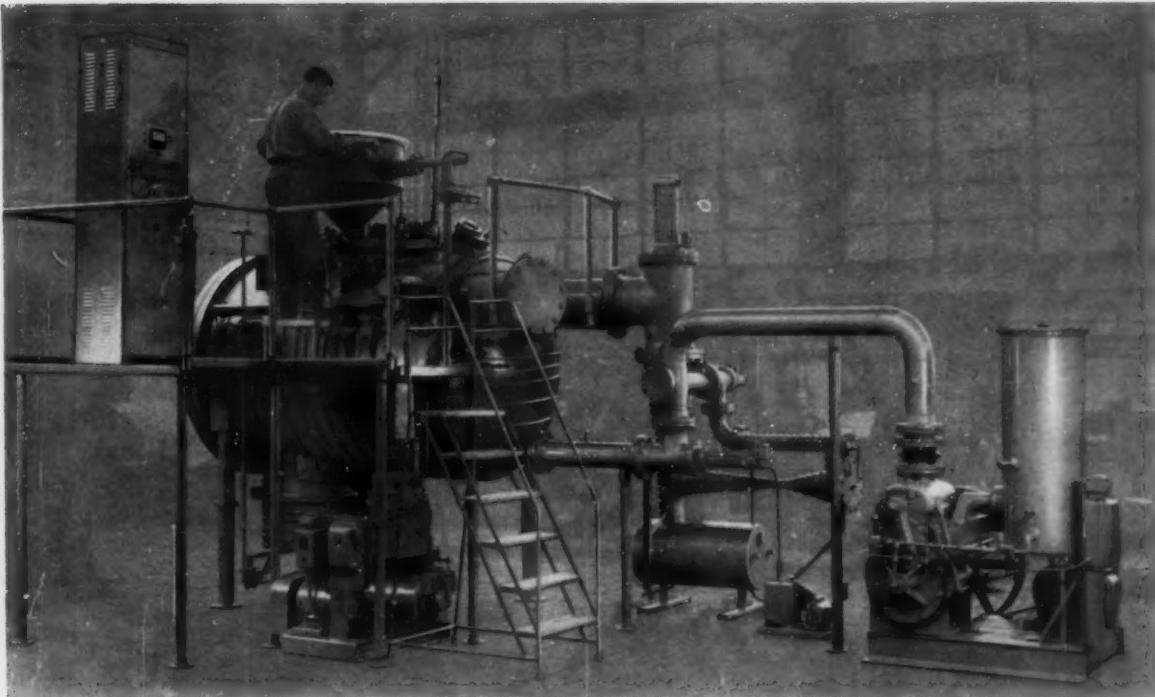


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MARKAL COMPANY • 3118 West Carroll Avenue • Chicago 12, Illinois



New modular-type vacuum induction furnace—Model FIM-300—50 to 300 pounds capacity.

Here's your special vacuum furnace

... it comes from our standard stock ... and it stays special

Like a lot of new fields, vacuum metallurgy is growing and changing fast, making it hard to plan processing that will match the market as years roll by.

Solution: Modular Furnaces

One sure answer to this predicament is to buy *modular* furnaces . . . units you can expand as the need arises. Such a furnace is our new 50 to 300-pound furnace.

It handles melts as small as 50 pounds efficiently. With the correct size crucible you can take the basic unit up to 300 pounds. Observation windows, a bridgebreaker, a charging cup with interlock, and a gauge-valve relay rack cabinet give you the controls you need for uncomplicated vacuum metallurgy.

If or when your needs call for even more critically controlled production, the basic unit is ready with built-in accommodations for such things as a sampling device,

immersion thermocouple, and optical sight tube.

Semi-continuous operation, too

There's a 12-inch flange above the crucible for adding a bulk-charging chamber. The 36-inch diameter mold well will take a 34-inch mold table. When you want to go to semi-continuous production, these two changes will greatly expand your output. For example, you could pour six 300-pound ingots—1800 pounds—without breaking vacuum.

The mold well, by the way, is flanged and can be provided in a variety of depths. Even with the standard well you can pour in molds 48" deep.

And so, if you want to break into vacuum metallurgy in a modest way with provisions for future expansion that will not sacrifice your initial investment, this is your furnace. Get to know it better by writing for our Bulletin P4-36.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N. Y.

formerly *Consolidated Vacuum*

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES





4 OF THE MANY STYLES OF THE
ONE-PIECE SEAMLESS DOOR KNOBS
FABRICATED FROM RUGGED
REVERE BRASS STRIP.

REVERE BRASS STRIP

Stands the Gaff!

The one-piece door knobs shown are drawn from a single blank of Revere Brass Strip, presenting an attractively smooth, unbroken surface without the need for seams or welds.

Because they are made by a unique procedure the manufacturer tells us that the brass must stand up under mighty rugged going, and that to produce the quality knobs they do, at an economical production level, the brass they use must have:

1. *Uniformity of gauge.*
2. *Absence of any sign of fracture or crimping when drawn.*
3. *Consistently correct grain structure to insure a smooth, flaw-free surface on the finished knobs.*

The manufacturer also tells us that Revere Brass Strip has been filling that bill, with utmost satisfaction, for some time.

Revere Brass Strip may be able to help you make a better product at less cost. You'll never know until you talk it over with one of our TA's (Technical Advisor). There's no obligation, of course. And such a discussion could save you a substantial sum of money. Such has been the case many, many times.



REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.



Results Guaranteed . . .

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. . . in our laboratory . . . on production equipment!

Take an active part . . . see the actual results . . . of procedures and equipment developed to suit your specific needs. We feel that the Hayes Laboratory is unique in what it offers . . . GUARANTEED RESULTS!

Here's why:

- Laboratory contains an extensive line of production heat treating equipment on which to develop customized plant procedures.
- If existing equipment does not meet specifications, new equipment will be designed and built to suit.

- You can draw from a reservoir of over fifty years of accumulated knowledge in this field . . . knowledge gleaned in developing the wide line of "Certain Curtain" electric furnaces and allied equipment.
- You can use our laboratory facilities . . . and the services of our entire staff . . . WITHOUT COST OR OBLIGATION . . . because we know that those introduced to the superior features of the C. I. Hayes line become steady customers and good friends. Act today . . . for GUARANTEED RESULTS!



An Added Convenience

The pilot of our four-place Beechcraft Bonanza plane will pick you up at any Eastern airport within a reasonable radius from our plant . . . and speed you to the home of profitable heat treating procedures.

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Free Bulletin

Please send me your new bulletin describing the facilities available to me at the C. I. Hayes Laboratory.

I am mostly concerned with the following heat treating procedures:

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| <input type="checkbox"/> High Speed Hardening | <input type="checkbox"/> Stainless Steel Heat Treating |
| <input type="checkbox"/> Tool Steel Hardening | <input type="checkbox"/> Sintering |
| <input type="checkbox"/> Carbo-Nitriding | <input type="checkbox"/> Copper Brazing and Soldering |
| <input type="checkbox"/> Tempering | <input type="checkbox"/> Lead Pot Hardening and Tempering |
| <input type="checkbox"/> Vacuum Heat Treating | <input type="checkbox"/> Atmosphere Equipment |
| <input type="checkbox"/> Bright Heat Treating | <input type="checkbox"/> Other _____ |

Name _____ Title _____

Company _____

Street _____

City _____ State _____

APPLICATION and EQUIPMENT

new literature

1371. Abrasion Tester

Bulletin 5409 on new model standard abrasion testing set describes machine and its operation. *Taber Instrument Corp.*

1372. Air Washers

Bulletin No. 256 on acid-proof air washers for ventilation systems. Construction and accessories. *Automotive Rubber Co.*

1373. Alloy Steel

68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

1374. Aluminum Bronze

8-page booklet on aluminum bronze bearing material which is forgeable, corrosion resistant, lightweight. *Mueller Brass*

1375. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1376. Aluminum Extrusions

Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

1377. Aluminum Melting

Folder on electric furnaces for the aluminum alloy foundry. *Ajax Engineering*

1378. Annealing Furnaces

8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

1379. Atmosphere Equipment

4-page bulletin on exothermic and endothermic gas generators, ammonia dissociator. *C. I. Hayes*

1380. Atmosphere Furnace

4-page description of furnace which heat treats, quenches and cools under controlled atmosphere. Furnace for solution heat treating of aluminum and oven for tempering springs. *W. S. Rockwell*

1381. Atmosphere Generators

New 4-page bulletin 1-457 includes flow charts and cost analyses of inert gas system. *Gas Atmospheres*

1382. Barrel Finishing

12-page booklet gives case histories, materials for barrel finishing. Equipment. *Minnesota Mining & Mfg. Co.*

1383. Batch-Type Furnaces

Bulletin SC-1 on mechanized controlled atmosphere furnaces. Three models diagrammed and described. *Dow Furnace*

1384. Bimetal Applications

44-page booklet, "Successful Applications of Thermostatic Bimetal", contains uses, formulas, calculations. *W. M. Chace*

1385. Blast Cleaning

Complete information on Malleabrasive for cleaning and finishing. *Globe Steel Abrasives*

1386. Boron Additive

6-page article on use of grainal as

boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

1387. Brazing

4-page reprint on gas-fired machine brazing. Case histories. *Selas*

1388. Brazing

4-page reprint on use of salt baths in production and small scale brazing of simple and complex assemblies. *Ajax Electric*

1389. Brazing

16-page pocket-sized guide to selective fluxing for low temperature silver brazing. *American Platinum*

1390. Brazing Alloys

Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

1391. Buffing and Polishing

24-page catalog on cutting, coloring and double duty compounds for 12 metals, plastics and rubber. *Hanson-Van Winkle-Munning*

1392. Carbides

15 data sheets on Carbmet carbide grades. Typical applications, analysis, physical characteristics and grain structure. *Allegheny Ludlum Steel Corp.*

1393. Carbon and Graphite

New 8-page bulletin on carbon and graphite for high temperature applications. Pertinent aspects of manufacturing process. *Speer Carbon Co.*

1394. Carbon Products

New 4-page bulletin on carbon and graphite products for the chemical processing and other industries. Pumps, valves, heat exchangers, etc. *National Carbon Co.*

1395. Carbon Refractories

Catalog section on carbon products for cupola furnaces gives physical properties of carbon refractories and describes applications. *National Carbon*

1396. Carburizing

16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

1397. Centrifugal Castings

12-page bulletin gives analysis of ferrous and nonferrous alloys in which centrifugal castings are available. *Sandusky Dryer & Machine*

1398. Centrifugal Pumps

Folder on new line of pumps. Features, engineering data. *General Ceramics*

1399. Ceramics

4-page bulletin D2-56 on physical properties of 10 industrial ceramics. Fabrication methods and important service features. *McDaniel Refractory Porcelain Co.*

1400. Chemical Analyzer

Data on Autrometer, automated

chemical analyzer. Performance, applications. *Philips Electronics, Inc.*

1401. Chromate Coatings

Data sheets on Luster-on 50 conversion coating for manual or automatic plating. Bath make-up, operating conditions, typical cycle. *Chemical Corp.*

1402. Chromate Finishing

File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

1403. Chromium Plating

Bulletin CFC-1 on advantages of crack-free chromium plating process. *Metal & Thermit Corp.*

1404. Cleaner

Service report on composition for reverse current cleaning of steel. Application cycle. *Oakite*

1370. Super-Strength Steels

Structural steels with yield strengths of 55,000 to 150,000 psi. are considered in this 20-page booklet. Of higher strength than the high-strength low-alloy steels as well as carbon struc-



tural steels, they have other advantages (depending on composition), including strength at moderate temperatures, toughness at low temperatures, corrosion resistance and wear resistance. The properties of 15 steels in this class made by 7 steel producers are charted. Compositions, forming characteristics and uses are included. *Climax Molybdenum Co.*

1405. Cleaners

4-page bulletin No. E-1 on five cleaners for power washers, soak tanks, electrolytic cleaning, emulsion cleaning. *Park Chemical*

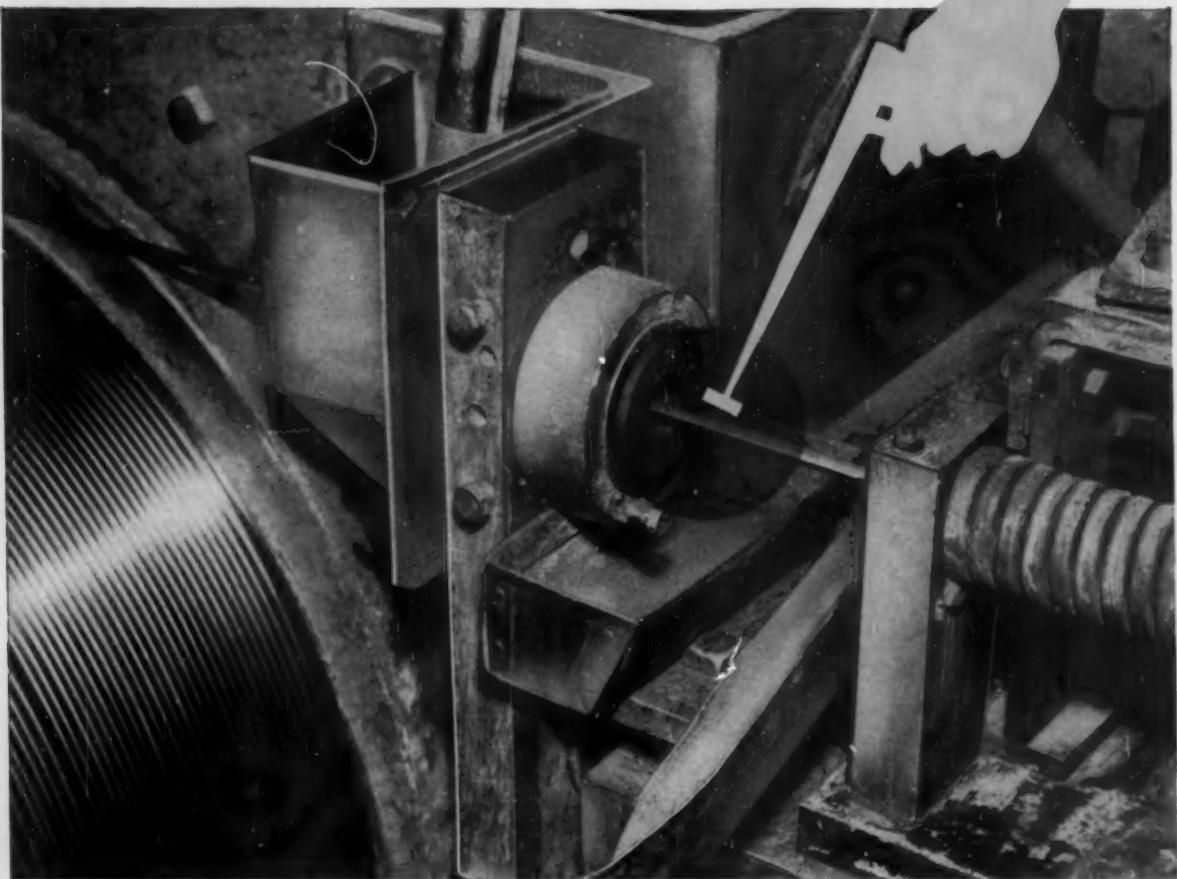
1406. Cleaners

Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

1407. Cleaning

8-page bulletin on surface active agents for the metalworking industry. Properties. *E. F. Houghton & Co.*

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1408. Coated Pipe

4-page folder on new plastic-coated steel pipe and tubing. How it solves the problem of pipeline corrosion. *Republic Steel*

1409. Cobalt Alloy

12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

1410. Cold Rolled Steels

32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

1411. Compressors

12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

1412. Construction Kit

Folder and 60-page booklet on construction kit of selected standard elements to be used in solving engineering problems and instruction. *C. R. Carlson Co.*

1413. Controller

Data sheet on thermocouple Electro-mechanical controller. Specifications. *Leeds & Northrup*

1414. Copper Alloys

40-page technical data book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

1415. Copper and Brass

New 60-page warehouse stock list gives items and sizes carried in stock. *American Brass*

1416. Copper Alloys

48-page book contains tables of alloys with composition, typical uses, general working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

1417. Copper Alloys

60-page catalog on phosphor bronzes, nickel silvers, beryllium copper, cupronickel. Chemical and physical data. Engineering tables. *Riverside-Alloy Metal*

1418. Creep Testing

Bulletin RR-13-54 on new creep testing machine. *Riehle*

1419. Creep Testing

Bulletin 4420 describes long-time creep test machines, creep-rupture machines and relaxation machines. *Baldwin-Lima-Hamilton*.

1420. Decimal Equivalents

2-color wall chart gives decimal equivalents. *Peninsular Steel Co.*

1421. Decimals

Wall chart 16 by 23 in. of decimal equivalents. *John Hassall, Inc.*

1422. Degreasers

Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

1423. Degreasing

Bulletin on OPNT vapor degreaser describes and diagrams its construction. *Circo Equipment*

1424. Descaling Titanium

Bulletin 25-T on salt descaling of titanium and titanium alloys. History, recommended procedure, problems. *Hooker Electrochemical*

1425. Dew Point Control

Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

1426. Disintegrators

Catalog B-1 on disintegrator which will remove embedded broken tools. Specifications. *Jiffy Disintegrator*

1427. Dryers

New 52-page Bulletin D-100 on dryers for air, gas and liquids for low dew points. *C. M. Kemp Mfg. Co.*

1428. Ductile Iron

2-page Bulletin 14 describes characteristics, production, effect of heat treatment, types. *Advance Foundry Co.*

1429. Electric Furnaces

Bulletin HD-153 on furnaces using silicon carbide heating elements for duty to 2600° F. *Hevi Duty Electric Co.*

1430. Electric Furnaces

Catalog of electric furnaces and ovens, for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

1431. Electric Furnaces

8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Perey*

1432. Electrocoated Wire

8-page bulletin on new wire materials—Nickelply and Brasply, electrocoated steel wire. How it may be formed, bent and twisted without breaking the coating. *National Standard*

1433. Electron Tubes

12-page bulletin on industrial use and proper care of electron tubes. Log sheets for tube life records. *Machlett Laboratories*

1434. Flow Measurement

8-page Bulletin SC-1022 on instrument for measurement of flow rate of air and gases. *Selas Corp.*

1435. Flow Meter

12-page bulletin 115 on meter for flow

metering and control. Tubes, floats, and accessories. Installation and maintenance. *Brooks Rotameter Co.*

1436. Flow Meters

Bulletin 203 on flow meter for gas used in heat treating. *Waukesha Eng'g*

1437. Fluoroscopy

New 6-page reprint on modern techniques for using electronic fluoroscopy in examination of metals. Mechanism of image intensification, effect of target size on X-ray image, penetration effectiveness of various methods. *Philips Electronics*

1438. Formed Shapes

26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

1439. Forgings

Series of articles on modern forging methods. *Hill Acme*

1440. Forgings

8-page bulletin on typical upset forgings. Advantages and metal saved. *Champion Rivet*

1441. Forgings

12-page booklet on how forged weldless rings and flanges are made. Case histories. *Standard Steel Works Div., Baldwin-Lima-Hamilton*

1442. Forgings

New folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

1443. Forgings

94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A Finkl & Sons*

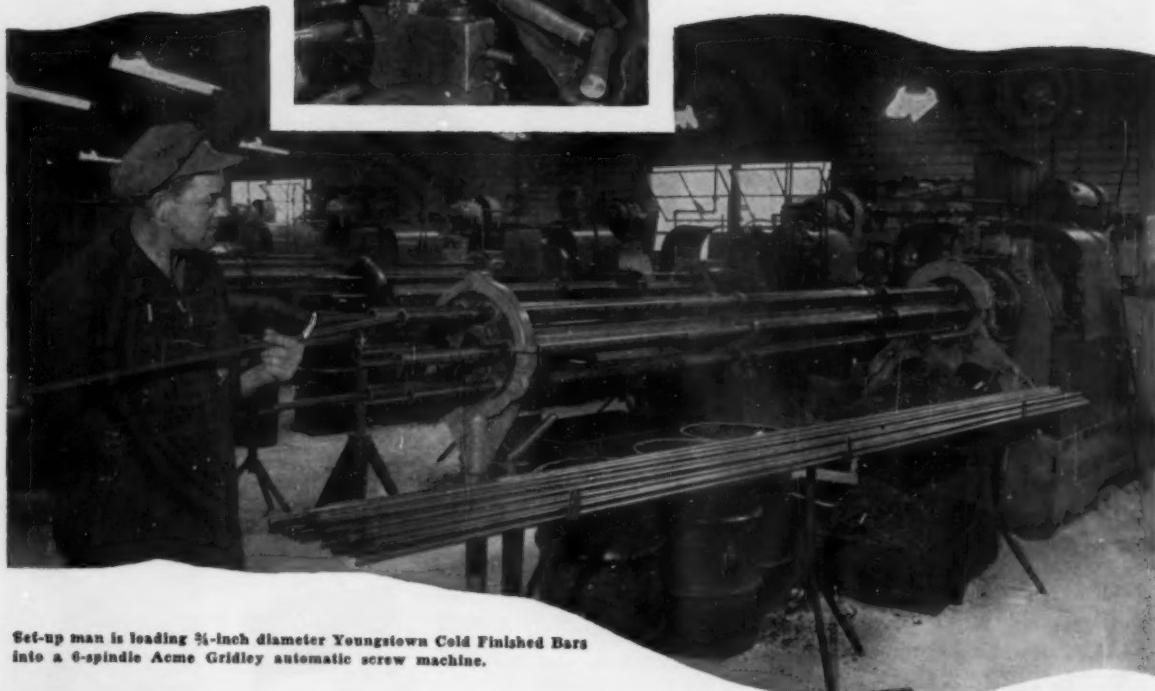
1444. Furnace

Description of new spheroidizing fur-

THE PRESSED STEEL CO. • Wilkes-Barre, Pa.

Studs for **NELWELD** process machined from Youngstown cold finished bars

Close-up of studs being bored to accommodate their charge of flux (top collet) and then cut-off (center collet). Two finished Nelweld studs, shown in the pan in foreground, were machined simultaneously in the 6-position machine. First operation—feed out and face; second—bore; and third—cut-off.



Set-up man is loading $\frac{3}{4}$ -inch diameter Youngstown Cold Finished Bars into a 6-spindle Acme Gridley automatic screw machine.

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Tool Steel
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Cold finished bars

Progressive fabricators rely on the Nelweld method for fast, dependable end-welding of studs to steel surfaces. This novel electric arc process—utilizing flux-filled steel studs—substantially reduces direct fastening costs when used to replace conventional time-consuming methods such as drilling, tapping, hard welding, through-bolting or the securing of straps and rivets.

To maintain their world-wide reputation for product quality and uniformity, Nelson Stud Welding, a division of Gregory Industries, Inc., uses Youngstown Cold Finished Bars as the basic material for stud production.

Youngstown Cold Finished Bars provide high machinability and greater uniformity of composition, structure and surface finish to help you increase production of more uniform parts. Always specify Youngstown—it's your best assurance of quality.

Why not call or write your nearest Youngstown District Sales Office today for additional information or metallurgical assistance?

nace installed at Budd Co., in Metal Minutes, Nov. 1956. Sunbeam Corp.

1445. Furnace

New bulletin on basic principles of electric furnace design. Cutaway models of 8 furnaces. Cost factors. Holcroft

1446. Furnace Charging

12-page brochure on eight models of charging machines for heating and melting furnaces. Salem-Brosius

1447. Furnace Fixtures

Bulletin 111 on cast Ni-Cr fixtures for gas carburizing. Fahr alloy

1448. Furnace Loader

Bulletin on loader for heat treat furnaces. Michigan Crane & Conveyor

1449. Furnaces

Bulletin 1250-T on bell retort furnaces describes atmosphere system, construction and dimensions. American Gas Furnace

1450. Furnaces

Bulletin on electric heat treating furnaces describes five series and accessories. Lucifer Furnaces

1451. Furnaces

Bulletin SC-179 on gas-fired muffle furnace. Application in bright heat treatment and brazing. Surface Combustion Corp.

1452. Furnaces

Catalog on standard and special furnaces and ovens to 3000° F. L & L Mfg.

1453. Furnaces

Data on radiant aluminum die casting furnaces. J. A. Kozma Co.

1454. Furnaces

Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. Waltz Furnace

1455. Furnaces

52-page book on gas, oil and electric pot furnaces. 16 pages of drawings of various types of furnaces. A. F. Holden

1456. Furnaces

Folder on recirculating furnaces illustrates and describes 9 models and endothermic gas generator. Standard Fuel Engineering Co.

1457. Furnaces

High-temperature furnaces for temperatures up to 2000° F. are described in bulletin. Carl-Mayer Corp.

1458. Furnaces

Lists of surplus furnaces for sale. Joe Martin Co.

1459. Furnaces, Heat Treating

12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. Electric Furnace Co.

1460. Galvanizing

Story of galvanizing fencing at Colorado Fuel and Iron in Metal Minutes, Aug.-Sept., 1957. Sunbeam

1461. Gas Blenders

Bulletin GB 8-57 on machine to control gas mixing. Gow-Mac Instrument Co.

1462. Gas Unit

Bulletin HD-257 on gas preparation unit gives gas composition and chemical reactions. Heri Duty Electric

1463. Gold Plating

Folder gives data on plating to obtain a hard bright gold finish. Technic, Inc.

1464. Graphite

6-page revised bulletin No. 435 on colloidal graphite for surface coatings and impregnation. Acheson Colloids

1465. Grinding Machine

Folder on grinding machine with con-

tinuous inspection. Specifications. Cleveland Grinding Machine Co.

1466. Hardfacing

New 8-page booklet on hardfacing electrodes gives chemical composition, properties, applications, procedures. Iron, cobalt base alloys and cast tungsten carbide. Haynes Stellite

1467. Hardness Numbers

Pocket-size table of Brinell hardness numbers incorporating other tabular information. Steel City Testing

1468. Hardness Tester

Bulletin on Brinell tester with test head for deep and offset testing. King Tester

1469. Hardness Tester

Catalog 72-1 on Leitz miniload tester for Vickers and Knoop hardness and standard hardness testers for Rockwell and Brinell tests. Opto-Metric Tools

1470. Hardness Tester

Data on hardness testing sclerometer with equivalent Brinell and Rockwell C numbers. Shore Instrument

1471. Hardness Tester

4-page bulletin on portable metal hardness tester for any shape or metal. Ranges, features. Newage Industries

1472. Hardness Tester

20-page book on hardness testing by Rockwell method. Clark Instrument

1473. Hardness Testers

4-page bulletin on hardness tester for regular and superficial Rockwell tests. Special features and accessories. Torsion Balance

1474. Hardness Testers

20-page bulletin on models, applications and how to use superficial hardness testers. Wilson Mechanical Instrument

1475. Hardness Testing

Bulletin No. A-18 on Alpha Co. Brinell hardness testing machines. Gries Industries

1476. Heat-Resistant Alloys

Catalog and stock list of sheets, plates and bars of heat-resistant alloys. Rolled Alloys, Inc.

1477. Heat Treating

Bulletin on completely mechanized heat treat lines. 24 basic mechanisms. Steps in building automated lines. Surface Combustion Corp.

1478. Heat Treating

Bulletin describes baskets, crates, trays, furnace parts for heat treating. Stanwood

1479. Heat Treating

8-page article on heat treatments for ductile iron. Process for developing tensile strength from 60,000 to 150,000 psi. and elongation to 25%. International Nickel

1480. Heat Treating

12-page bulletin on heat treating equipment. Applications and special features of 19 different types of furnaces including shaker hearth, conveyor, high vacuum, elevator-type brazing. Pacific Scientific

1481. Heat Treating

Monthly bulletin on used heat treating and plating equipment, available for immediate delivery. Metal Treating Equipment Exchange.

1482. Heat Treating

New 24 page catalog on effect of steam atmosphere heat treating on various metals. Leeds & Northrup Co.

1483. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. Nitrogen Div.

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FOR FERROUS METAL-MELTING

Type of equipment	metals melted	use of cement	Norton cement recommended			how applied
			number	maturity temperature		
indirect arc	alloy iron and steels	lining	RA 1307	1150°C	2100°F	rammed
		patching	RA 1307 RA 1162	1150°C 1000°C	2100°F 1850°F	rammed rammed
direct arc	alloy steel and malleable iron	troweling around electrodes	RA 1162	1000°C	1850°F	trowled
		lining roof and around electrodes	RA 1307	1150°C	2100°F	rammed
high frequency induction	stainless steel and refractory alloys	lining	RM 1170	1150°C	2100°F	rammed (dry)
		patching large furnaces	RM 1152	1200°C	2200°F	rammed
		patching small furnaces	RM 1992	1100°C	2000°F	troweled or rammed
ladles	iron and steel	lining	RA 1307	1150°C	2100°F	rammed

FOR NONFERROUS METAL-MELTING

low frequency induction	Al, Te, Si bronzes	lining	RM 1140	1250°C	2300°F	rammed
	general purposes	lining	RA 1307	1150°C	2100°F	rammed
indirect arc	brasses and bronzes	lining and patching	RA 1307	1150°C	2100°F	rammed
crucible melting furnaces ■	brasses and bronzes	lining and patching	RC 1188	1100°C	2000°F	rammed
reverberatory furnaces ▲	brasses and bronzes	lining and patching	RC 1188	1100°C	2000°F	rammed

■ Cement not in contact with metal; used in combustion chamber. ▲ Cement in contact with metal.

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1484. Heat Treating Belts

Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

1485. Heat Treating Fixtures

Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1486. Heat Treating Fixtures

4-page folder on rotors, baskets, trays, carburizing boxes, fans for heat treating. *Aluminum & Architectural Metals Co.*

1487. Heat Treating Fixtures

12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1488. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1489. Heat Treating Fixtures

New 32-page catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heating-treating equipment, pickling equipment. *Rolock*

1490. Heat Treating Supplies

Data sheets on carburizing, hardening, tempering, nitriding salts, metal cleaning and rust prevention materials. *Heatbath*

1491. Heaters

Bulletin on immersion heaters for electroplating solutions. *Glo-Quartz*

1492. Heaters

16-page publication GEA-5866 gives case histories of use of tubular heaters in shrinking machinery, extruding machines, radiant ovens and paint heaters. *General Electric*

1493. High-Strength Steel

New 24-page bulletin on steel bars made by elevated temperature drawing. Strength without heat treatment, machining data, fatigue resistance, wearability. *LaSalle Steel*

1494. High-Strength Steel

26-page booklet on properties, uses, applications of high-tensile low-alloy steel. *Jones & Laughlin*

1495. High-Temperature Alloy

14-page bulletin on Udimet 500 gives composition, heat treatment, machinability, hot working characteristics and properties. *Utica-Metals Div.*

1496. High-Temperature Belts

Bulletin T-241 on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys*

1497. High-Tensile Steel

8-page bulletin on properties and composition of N-A-X high-tensile steel. Examples of resistance to impact, fatigue, abrasion and corrosion. *Great Lakes Steel*

1498. Induction Heater

New 8-page bulletin on 60-cycle induction heater for aluminum, copper, brass and steel. Installations, billet heater selection chart for aluminum. *Magnethermic Corp.*

1499. Induction Heating

Folder 15C8053C gives advantages of induction heating and specifications and dimensions of induction heater. *Allis-Chalmers*

1500. Induction Heating

New bulletin on remote heating station for motor generator induction heating equipment. *Lindberg Engineering Co.*

1501. Induction Heating

12-page booklet B-6519 on equipment for induction heating for forging, hardening, annealing and metal joining. *Westinghouse Electric*

1502. Induction Heating

60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1503. Induction Melting

Bulletin 70 on furnace. Controls, designs. *Inductotherm Corp.*

1504. Insulating Firebrick

8-page bulletin R-43 gives description of relationship between heat losses and weight of refractory lining. *Refractories Div., Babcock & Wilcox*

1505. Lab Test Dies

Complete information on multi-motion laboratory test specimen dies. *Haller*

1506. Laboratory Equipment

New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

1507. Laboratory Equipment

16-page Laboratory Spotlight lists optical equipment and instruments for metallurgical laboratory. Cut-off machines, polishing tables, etc. *Harshaw Scientific*

1508. Laboratory Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

1509. Laboratory Instruments

20-page booklet on gage laboratory instruments. Layout of a gage laboratory. Description of each instrument. *Sheffield*

1510. Leaded Steels

New 16-page booklet on basic characteristics, mechanical properties and workability of leaded steels. Case histories. *Copperweld Steel Co.*

1511. Low-Alloy Steel

60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U.S. Steel*

1512. Low-Carbon Stainless

"Melting Low-Carbon Stainless Steel" shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical Corp.*

1513. Lubricant

8-page booklet, "Biggest Ounce of Protection", tells of lubrication with colloidal graphite products. *Grafo Colloids*

1514. Lubricants

16-page brochure on history and development of molybdenum disulfide lubricants. Selection table, uses, bonded solid film lubricating coatings. *Alpha Molykote Corp.*

1515. Machining Alloy Steels

24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

1516. Machining Copper

12-page bulletin on machining properties, practices, feeds, speeds, tool design. *Ampeco*

1517. Machining Stainless

New pocket-size slide chart on how to machine the popular grades of stainless. Workability of stainless in blanking, deep drawing, stamping, forging, etc. *Carbenter Steel*

1518. Machining Titanium

8-page bulletin on turning, milling, drilling, tapping, grinding. Recommendations for each. Typical properties of titanium. *Mallory-Sharon Titanium Corp.*

1519. Magnesium

42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

STRAITS TIN REPORT



New developments in the production, marketing and uses of tin

A tin "doughnut" is now being used to reduce water evaporation from reservoirs—an important conservation measure in our chronic, and growing, shortage of water. It dispenses flakes of hexadecanol, which lab studies indicate reduces evaporation losses up to 65%. This "doughnut" is a tub-shaped device without top or bottom, and 6 feet in perimeter. The outside surface is brass screen and the inside surface sheet tin. It is supported by means of inflated plastic bags.

* * * *

By using modern printed circuit soldering techniques, British scientists have now developed a radar receiver so compact it occupies no more than 170 cubic inches, a small fraction of a cubic foot.

Development of a new tin field near Kampar, Perak, in the Federation of Malaya, may be undertaken shortly. The field is reported to contain millions of dollars' worth of tin ore.

Add one more "product" to the growing list now supplied in tin cans. This time it's fresh Florida air, packed as a souvenir by a novelty company in the Sunshine State.

* * * *

The International Tin Council recently estimated that the surplus of tin from world production this year will be between 5000-7000 long tons. Thanks in large part to the International Tin Agreement, prices have fluctuated only between 1% and 2% since the beginning of 1957. This new price stability, in the opinion of many, makes tin an even more useful material in any plans for the future.



Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau

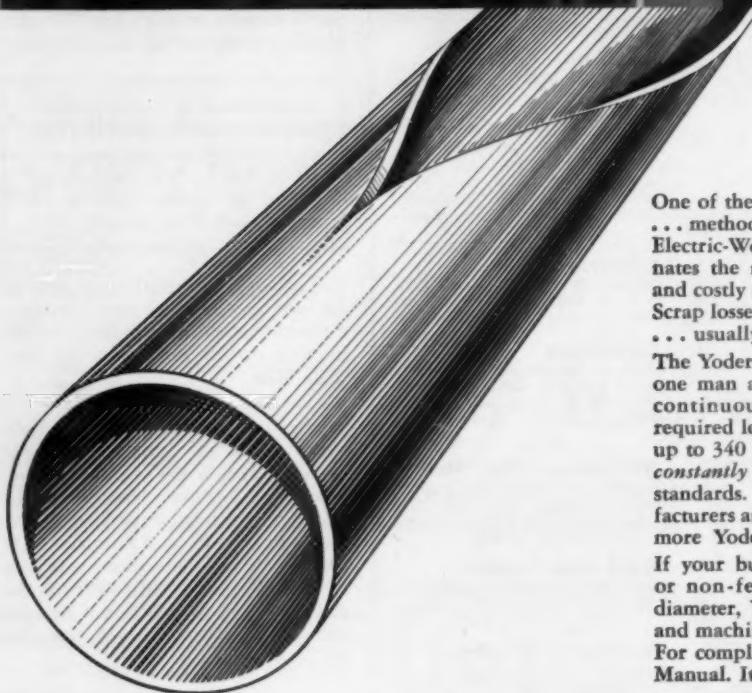
Dept. 251, 1028 Connecticut Ave., Washington 6, D.C.

from cold strip to finished tubing

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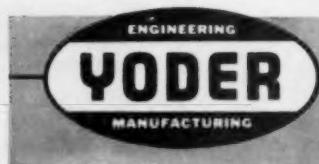
ELECTRIC-WELD TUBE MILL



One of the fastest . . . and one of the least expensive . . . methods of making steel tubing is with a Yoder Electric-Weld Tube Mill. The Yoder method eliminates the need for time-consuming heat treatments and costly conditioning furnaces for most tube needs. Scrap losses, too, are far lower than any other method . . . usually less than 2%.

The Yoder Type-M Mill shown above is operated by one man and a helper. Coiled strip on this mill is continuously cold-roll formed, welded and cut to required lengths in a matter of seconds . . . at speeds up to 340 f.p.m. The quality of the resulting tube is constantly better than the requirements of commercial standards. This is one of many reasons why manufacturers and users of tubing the world over are using more Yoder mills than all other makes combined. If your business requires pipe and tubing, ferrous or non-ferrous, in sizes from $\frac{1}{4}$ -inch to 26-inch diameter, Yoder can supply the engineering service and machines to produce it faster and better for less! For complete details, write for the Yoder Tube Mill Manual. It's yours for the asking.

THE YODER COMPANY
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PIPE AND TUBE MILLS (ferrous or non-ferrous)

COLD ROLL FORMING MACHINES

ROTARY SLITTING LINES

1520. Magnesium-Zirconium
10-page reprint on an investigation of zirconium chloride, zirconium fluoride, 40% zirconium-magnesium material for making magnesium-zirconium alloys. Titanium Alloy Mfg. Div.

1521. Malleable Iron
Brochure on selection of standard and perlitic malleable iron castings. Cost savings through the use of malleable. Malleable Founders' Society.

1522. Manganese
9-page article on electromanganese. Manufacturing procedures, product characteristics, uses. In Foote Prints, V. 28, No. 2. Foote Mineral Co.

1523. Marking Metal
Bulletin on electromark process. Equipment. Operating instructions. Electro-mark Corp.

1524. Meehanite Castings
4-page data folder on heat treatment of different grades of Meehanite castings. Improving strength, toughness and hardness. Austempering, martempering. Meehanite Metal Corp.

1525. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. Lindberg Engineering Co.

1526. Melting Furnaces
48-page book 9A on line of standard furnaces from research to 200-ton steel mill types. Lectromelt Furnace Div.

1527. Metal Forming
Folder on rolling mills, swaging machines, wire shaping mills, wire and tube drawing machines. Fenn Mfg.

1528. Metallograph
12-page bulletin on desk-type and research metallographs. Accessories, illuminating systems, specifications. American Optical

1529. Metalworking Saws
New 64-page catalog 31 on burs, files, grinding points, metalworking saws, voltmeters, electric etchers. Martindale Electric Co.

1530. Microhardness Tester
Bulletin describes the Kentron microhardness tester. Torsion Balance Co.

1531. Microscopes
Catalog of metallograph and several models of microscopes. United Scientific

1532. Molybdenum Alloying
1-page chart gives weight of ferro molybdenum addition needed by foundry for molybdenum contents in castings up to 1.50%. Climax Molybdenum

1533. Nitriding
Data on process for nitriding stainless steel. Standard Steel Treating

1534. Nondestructive Testing
8-page bulletin on equipment for non-destructive testing of bars, rods, tubing. Magnetic Analysis.

1535. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. Production Specialties

1536. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. Aldridge Industrial Oils

1537. Openhearts
12-page booklet shows how openhearts are built. Furnace binding, refractories, combustion and controls, and mechanical equipment. Loftus Engineering

1538. Optical Instruments
Ways to use optical instruments in manufacturing and inspection. Magnifiers, microscopes, wide field tubes, mac-

roscopes and comparators discussed. Bausch & Lomb Optical

1539. Ovens
New 16-page bulletin 157 on ovens for baking, drying, curing and heat treating. Batch and conveyor types. Air recirculating and heating systems. Young Brothers Co.

1540. Perforated Metals
New 4-page folder gives ordering specifications and patterns. Wickwire Spencer Steel Div., Colorado Fuel and Iron Corp.

1541. Permanent Magnets
New 12-page booklet on permanent magnets. Thermistors and Thyrite varistors tell how they can be used in design of electrical equipment. Metallurgical Products Dept., General Electric Co.

1542. Phosphating
Folder on phosphating and metal pro-

tective coating materials. Purpose and make-up of each type of coating. Turco

1543. Photomicrography
Catalog E-210 on sliding base, high or low power photomicrographic equipment. Bausch & Lomb

1544. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. Jellif

1545. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. Youngstown Welding & Eng'g

1546. Plating
New 8-page bulletin on automatic plating and anodizing machine. Deposition charts for nickel, tin, zinc, cadmium, copper. Lasalco, Inc.



WORLD'S LARGEST OPEN HEARTH FURNACE

Designed and Built By Loftus

Late in 1956, the largest open hearth furnace in the world was tapped at Weirton Steel Company, Division of National Steel Corp., Weirton, W. Va.

Designed and built by Loftus Engineering Corp., this huge furnace has a rated capacity of 600 tons, is approximately 111 feet long by 30 feet wide, and construction was completed in less than a

year. Operation is simple since the furnace is equipped with full automatic control.

If you are planning expansion or modernization of your heating facilities (ferrous or non-ferrous), we would like to demonstrate how Loftus' long experience in furnace design and construction can benefit you. Write us today. There is no obligation.

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57.8.3 A

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**Commercial-grade zirconium sponge
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See us at the Chemical Show, Dec. 2-6, Booth No. 1044

1547. Polishing

12-page discussion, "A Practical System for Preparing Metallographic Specimens", from Metal Digest, V. 2, No. 3. Buehler

1548. Powder Metallurgy

8-page reprint on parts made by sintering powdered metals. Advantages and limitations of the process. Surface treatment. Pegasus International Corp.

1549. Powdered Metals

Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. New Jersey Zinc

1550. Powdered Metals

New 12-page booklet on advantages of powder metal parts, how they are made, design, production. Dixon Sintaloy

1551. Precious Metals

Data on bright gold, bright silver, rhodium plating and salts. Sel-Rez

1552. Precision Casting

8-page bulletin on investment castings of various ferrous and nonferrous alloys. Engineered Precision Casting

1553. Precision Casting

12-page book on alloy selection and design for investment casting. Arwood Precision Casting

1554. Precision Finishes

Technical data folder on Roto-Finish process, chips and compounds. Line of standard and special machines. Roto-Finish Co.

1555. Protective Coatings

Folder 301 on industrial protective coatings of rubber, neoprene and other materials. Arcos Steel Fabricators

1556. Pyrometers

Data sheet 1E-1 on high resistance indicating pyrometers. Special thermocouples for surface measurement, molten nonferrous metals, general immersion. West Instrument Corp.

1557. Quenching Oils

4-page bulletin on 3 types of quenching oil gives advantages of each. E. F. Houghton & Co.

1558. Radiography

16-page booklet on materials and accessories for industrial radiography. Guide to selection of film. Recommended development techniques. Eastman Kodak, X-Ray Div.

1559. Radiography

20-page bulletin on gamma radiography. Uses, sources, equipment. Nuclear Systems Div., Budd Co.

1560. Rare Earth Metals

29 references to recent applications of the rare earth metals in iron, steel and other ferrous alloys. New Process Metals

1561. Rare Earths

12-page handbook on rare earth chemicals, thorium. Applications of rare earths. Heavy Minerals Co.

1562. Recirculating Furnace

Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. Industrial Heating Equipment Co.

1563. Refractories

New bulletin, 1992, on two high temperature Alundum castable refractories. Properties and how to use them. Norton

1564. Refractories

New refractory catalog sheets on Diblo-D refractory brick and Refracrete castable. Refractories Div., Gladning, McBean & Co.

(Continued on page 48-A)

BERYLLOMETAL

QMV Brand . . .

High Strength-to-Weight Ratio
Rigidity, Dimensional Stability,
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High Melting Point
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THE BRUSH BERYLLIUM COMPANY, 4301 PERKINS AVE., CLEVELAND 3, OHIO



View through door of a press forge furnace showing B&W Insulating Firebrick walls and arches and B&W 80 Firebrick floor. The burners and flues are visible on the back wall.

B&W Insulating Firebrick reduce fuel costs 15% and increase production

Experience paid off for this major steel producer. Aware of the benefits of B&W Insulating Firebrick in his drop forge furnaces, he built two new press forge furnaces with lightweight B&W IFB linings. The results were a minimum average fuel saving of 15% and increased production, since the entire heating process for certain grades of steel could now be accomplished in one operation. Here's why.

The lightweight and consequent low heat storage of B&W IFB linings keep the furnace walls at a uniform tem-

perature to provide the most efficient heating conditions. Unlike heavier constructions, B&W Insulating Firebrick linings attain a uniform temperature faster with less fuel consumption.

In addition, B&W IFB linings respond quicker to temperature changes, permitting more accurate temperature control. In this instance, this not only prevented the cracking of tool and stainless steels, but helped reduce the total heating cycle, increasing production.

These forging furnaces use a 9"

B&W REFRactories PRODUCTS: B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics, and Mortars • B&W Silicon Carbide • B&W Ramming Mixes

B&W K-30 IFB wall backed up by B&W K-20 IFB. The K-30 is used as face brick because of its high temperature resistance. The K-20 is used as a backing because of its high insulating value. The hearth floor is of B&W 80 Firebrick for abrasion resistance and resistance against attack by mill-scale at the temperatures involved. Door linings are of B&W Kaocast and B&W Kaolite.

R-583



(Continued from page 47)

1565. Refractories

16-page catalog 101 on mullite refractories. Applications, ramming mixes, refractory mortars, patching mixes, castable refractories. Reference chart. Refractories Div., H. K. Porter Co.

1566. Refractories

40-page book lists super-refractories for heat treating furnaces and gives data on use in different kinds of furnaces. Refractories Div., Carborundum

1567. Refractory

Bulletin on castable refractories. How to use them. Properties of four types. Standard Fuel Engineering

1568. Resistance Alloy

New 16-page catalog on 60-16 nickel-chromium-iron alloy. Heating element design factors. Hoskins Mfg. Co.

1569. Rust Prevention

Bulletin No. 51 on anionic surface active agent for oil-soluble rust and corrosion inhibitors, emulsifying, wetting and dispersing agents. Sun Oil Co.

1570. Rust Prevention

Data sheets describe solvent type and emulsifiable type rust resisting compounds. John Swift Chemical

1571. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. Upton

1572. Sand Blasting

4-page bulletin 1256 on sand blasting machines for cleaning, deburring, surface preparation. Leitman Bros.

1573. Saws

Catalog C-55 describes 35 models of metal-cutting saws. Armstrong-Blum

1574. Sodium

40-page booklet on handling metallic sodium gives typical sodium-using processes, equipment installation, recommendations for pumping and instrumentation. U.S. Industrial Chemicals

1575. Sonic Thickness Tester

Measurement of wall thickness from one side by sonic method. Branson

1576. Spark Testing

20-page spark test guide features spark diagrams of 13 standard tool and die steels. Carpenter Steel

1577. Spring Wire

Selector guide for nickel alloy spring wire. Methods of heat treatment, proc-

essing of springs, stress relieving, annealing. Techalloy Co.

1578. Springs

Article in June-July 1957 Mainspring on hardening of beryllium-copper springs. Associated Spring Corp.

1579. Stainless Castings

Bulletin on advantages of corrosion-resistant castings. Ohio Steel Foundry

1580. Stainless Fasteners

New 24-page catalog 56-A lists sizes and types. 7000 items included. Star Stainless Screw

1581. Stainless Steel

Data sheet on Type 301 gives physical properties, corrosion and oxidation resistance, mechanical properties. Allegheny Ludlum

1582. Stainless Steels

12-page booklet on heat treatment of stainless steels. Operating data for annealing and handling. Physical property data. Pickling and descaling. Crucible Steel Co.

1583. Stainless Steel

28-page book on Type 430 nickel-free chromium stainless — properties, surface characteristics, fabrication, applications. Washington Steel Corp.

1584. Stainless Steel

New 28-page booklet on properties and applications of 17-4PH and 17-7PH stainless. Fabricating procedures. Armco Steel Corp.

1585. Stainless Steel

32-page catalog gives chemical composition, strength factors, physical properties and applications of 200, 300, 400 series stainless. Sharon Steel

1586. Stainless Tubing

12-page brochure on stainless steel heat exchanger and condenser tubes. Manufacture, chemical composition and analysis. Republic Steel

1587. Stainless Wire

32-page aid to selection of proper stainless steel wire for particular application discusses austenitic, ferritic and martensitic grades. Crucible Steel

1588. Steel

Bulletin on Yoloy C, corrosion resistant low alloy steel. Chemical analysis and properties. Youngstown Sheet and Tube

1589. Steel

Data sheet on high-purity 52100 steel, made by vacuum melting. Vacuum Metals

1590. Steel

14-page manual on sizes and types of electric furnace steel. List of products equipped to roll. A. M. Byers

1591. Steel 52100

Stock list on 52100 tubing, bars and ring forgings. Peterson Steels

1592. Steel Bars

12-page paper on effect of copper, abnormally heavy drafts, furnace treatment and die practice on Stressproof steel bars. Bibliography. LaSalle Steel

1593. Steelmaking

Beautifully illustrated brochure on steel-making, annealing, hot rolling, finishing. Rotary Electric Steel

1594. Sub-Zero Treatment

12-page booklet on industrial chilling equipment for shrinking, testing and treating of metals. Cincinnati Sub-Zero Products

1595. Sulphur Determination

Literature on 3-min. determinator for use with combustion furnace. Dietert

1596. Temperature Control

4-page bulletin on Pyrotac for automatic protection against excess temperature. Wiring is diagrammed. Illinois Testing Laboratories, Inc.

1597. Temperature Measuring

Bulletins on Tempilstiks and Tempilaq describe products and tell how to use them. Tempil Corp.

1598. Temperature Measuring

New folder on metal probe thermometers. Types, specifications, accessories. Royco Instruments

1599. Test Bars

18-page bulletin No. 168 on design of test bar patterns, production of test bars, testing procedures. Federated Metals Div., American Smelting and Refining

1600. Testing Instruments

16-page bulletin on portable recorders, voltmeters and ammeters, surface roughness scales and other electric testers. General Electric

1601. Testing Machines

12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. Detroit Testing Machine

1602. Textured Metal

16-page booklet on advantages and applications of textured metal. Rigidized Metals

HOLCROFT • BLAZING THE HEAT TREAT TRAIL FOR OVER 40 YEARS



Furnaces, F.O.B. Detroit
... today and yesterday



HOLCROFT "delivers the goods"

Back in '27, Holcroft, even then a company with many years of experience to its credit, custom-designed, built and delivered the electric, non-metallic heated walking beam furnace shown in the oval above . . . and at that time it was the most advanced, efficient furnace of its type then on the market.

Today, Holcroft is still "delivering the goods" . . . in the instance illustrated, a radiant-tube heated pusher type gas-carburizing furnace for automotive transmission parts. In the transition from the old to the new, it is worthy of note that Holcroft contributed substantially to the application of radiant-tube heating to continuous furnaces and pioneered in the development of gas carburizing. The basic principle, in fact, on which all modern gas-carburizing furnaces operate was disclosed by Holcroft engineers in 1935.

The same pioneering spirit is a guiding principle at Holcroft today. And when this "spirit" is combined with the experience, the research, engineering and manufacturing facilities that Holcroft offers, you can readily see why it pays to let Holcroft handle all phases of your heat treat furnace projects. May we be of assistance to you?

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J & L**RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL**

for Spring Steel Requirements such as these...

**FORMED PARTS
FOR HEAT TREATMENT**

SIZE	8 x .036
ANALYSIS	1050
FINISH	Bright
HARDNESS	Rockwell B-78 Max.
THICKNESS TOLERANCE	± .0003 incl. crown
WIDTH TOLERANCE	± .005
MICROSTRUCTURE	Uniform spheroids
COIL SIZE	16" I.D. coils large as possible
PACKAGING	On skids — shrouded

**FLAT PARTS FOR HIGH STRENGTH
WITHOUT HEAT TREATMENT**

SIZE	10 x .020
ANALYSIS	1075
FINISH	Bright
HARDNESS	Rockwell C-30 Min.
THICKNESS TOLERANCE	± .001 incl. crown
WIDTH TOLERANCE	± .005
MICROSTRUCTURE	Small fine carbides
COIL SIZE	16" — I.D. Max. coil wt. 1000#
PACKAGING	On skids — shrouded

SIZE 14 x .040

ANALYSIS	1095
FINISH	Bright
HARDNESS	95 to 105 Rockwell B suitable for blanking
THICKNESS TOLERANCE	± .0005 incl. crown
WIDTH TOLERANCE	± .005
MICROSTRUCTURE	Uniform medium size spheroids
COIL SIZE	16" — I.D. Max. coil wt. 600#
PACKAGING	On skids — shrouded

Knowing exactly what you require for most efficient fabrication and most effective product performance, J&L can set up and consistently meet restricted specifications to match your most exacting demands. Often production operations can be greatly simplified or even eliminated; in most instances end-product and/or assembly costs can be reduced and quite frequently, product quality improved.

We would welcome an opportunity to explore with you the possibilities of J&L Restricted Specifications applied to your strip steel requirements.

**FOR 4 IN 1 SERVICE ON YOUR
COLD ROLLED STRIP STEEL**

Now there are four J&L plants with facilities for production of "Restricted Specification" cold rolled strip. Strategic locations at Youngstown, Indianapolis, Los Angeles and Kenilworth, N.J., provide the security of 4 sources of supply plus the close working relationship which these local production centers make possible.



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DETROIT • INDIANAPOLIS • CHICAGO • LOS ANGELES • SAN FRANCISCO

FORMERLY THE COLD METAL PRODUCTS COMPANY

1603. Thermocouple Assemblies

New Bulletin No. TA-457 gives sizes, prices, ordering information. *Claud S. Gordon*

1604. Thermocouple Data

New bulletin F-5228-3 on construction and application of thermocouples and radiation detectors to industrial control. How to check, make, select and size thermocouples. *Wheelco*

1605. Thermocouples

Bulletin on miniature shielded thermocouples. Uses, calibrations, temperature ranges, materials of construction. *Thermo Electric*

1606. Thickness Gage

Folder on pocket-size gage. How to use it. *Ferro Corp.*

1607. Thickness Tester

Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

1608. Tin

20-page bulletin on importance of tin to the American industry. Applications in aircraft, chemical, container, electrical, electronic equipment and others. *Malayan Tin Bureau*

1609. Titanium

New bulletin on titanium production and use. Mechanical properties. *Republic Steel Corp.*

1610. Titanium

New 4-page brochure on titanium for anodizing racks. *Johnston & Funk Titanium*

1611. Titanium Alloy

12-page booklet on C-120AV titanium alloy. Physical properties, elevated-temperature properties, creep, fatigue, welding, machining, heat treatment. *Rem-Cru*

1612. Tool and Die Steels

26-page book on six oil and air hardening steels for high-production tools and dies. Many uses illustrated. *Bethlehem Steel*

1613. Tool Steel

Wall chart showing more than 300 varieties of tool steel with trade name of manufacturers. *Vulcan Crucible Steel*

1614. Tool Steels

Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand cast-

ing, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

1615. Tool Steels

13-page directory of tool and die steels gives SAE designations with compositions, properties, forging and heat treating data, trade names. *Cannon-Muskegon*

1616. Tool Steels

New 16-page booklet on tool steels, their application and heat treatment for the die casting process. *Crucible Steel*

1617. Tube Bending

24-page catalog on plant processes and products. List of bending dies and data on minimum bend radii. *American Tube Bending Co.*

1618. Tubing

Bulletin 3 on small tubing for industry. Sizes, alloys, tempers, tolerances. *Precision Tube Co., Inc.*

1619. Tubing

Data Memorandum No. 4 on large diameter thin-wall tubing in seamless and Weldrawn grades. Applications. *Superior Tube*

1620. Tubing

Technical data card 152-A on alloy steel pipe, tubing and welding fittings, for pressure uses. Analysis, properties, fabrication. *Babcock & Wilcox*

1621. Tubing

12-page booklet on tubing for the refrigeration industry. Spun end and finned tubular products. *Wolverine Tube*

1622. Tubing

64-page handbook on use of tube mills in manufacture of pipe and tube. Step-by-step description of the electric-weld process. *Yoder Co.*

1623. Ultrasonic Testing

6-page folder on immerscope diagrams instrument and tells how it may be used. *Curtiss-Wright Corp.*

1624. Vacuum Calculator

Slide rule for quick calculation of data necessary in vacuum engineering and processing—for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. *F. J. Stokes Machine*

1625. Vacuum Furnaces

Bulletins P8-20 and P4-28 on vacuum arc melting furnaces and pumps. *Consolidated Electrodynamics*

1626. Vacuum Metallizing

8-page catalog 551 on production and

November, 1957

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experimental-type metallizing units. *High Vacuum Equipment Corp.*

1627. Vacuum Pumps

16-page catalog 757 on construction, dimensions, capacities, performance curves for rotary positive air and vacuum pumps, gas boosters. *Leiman Bros.*

1628. Vacuum Pumps

52-page catalog No. 425-B on high-vacuum pumps contains formulas and tabular data. *Kinney Mfg. Co.*

1629. Welding Electrodes

4-page folder on physical properties as welded, analysis, tensile strength, elongation, hardness and uses of gas welding rods, bare electrodes, welding wire and metal spray wire. *Page Steel & Wire Div., American Chain & Cable Co.*

1630. Welding Electrodes

84-page pocket-size booklet describes characteristics, coating, sizes of various electrodes and compares them with standard electrode designations and other electrode brand names. *Harnischfeger*

1631. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1632. Welding Stainless

8-page booklet GET-1955 gives arc-welding practices for stainless steels. *General Electric*

1633. Welding Stainless

New 12-page booklet—a guide to better welding of stainless steels. In question and answer form. *Arcos Corp.*

1634. Wire Cloth

80-page booklet on applications, meshes, baskets, filters. *Cambridge Wire Cloth*

1635. X-Ray Equipment

12-page booklet on 250-kv. constant potential X-ray equipment for internal inspection. Advantages, design features. *Westinghouse Electric*

1636. X-Ray Equipment

28-page booklet on products for industrial radiography gives exposure and processing data for various films used. *DuPont*

1637. X-Ray Unit

Bulletin on portable X-ray unit. Description of unit and accessories. *Balteau Electric Corp.*

1638. Zirconium

7-page bibliography on properties of zirconium and its alloys. *Columbia-National Corp.*

METAL PROGRESS,

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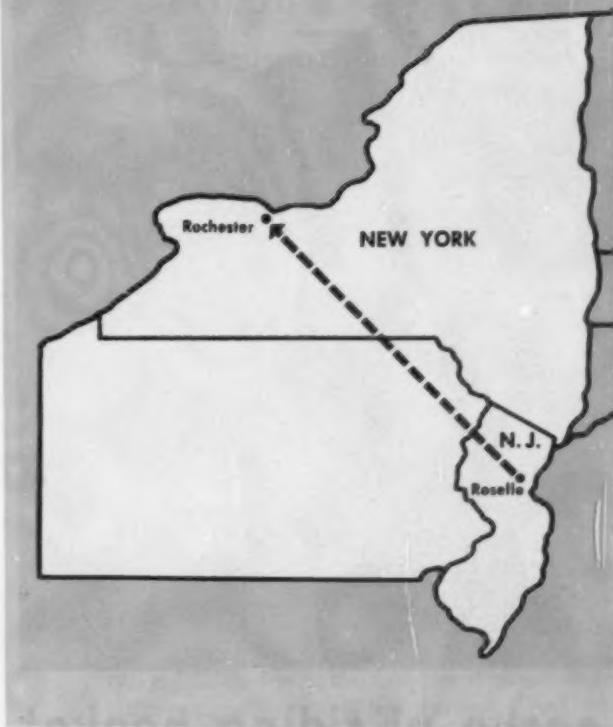
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Name _____

Title _____

Company _____

Watson-Stillman Press Division is moving to Rochester



EFFECTIVE NOVEMBER 1, 1957, the engineering, sales and service headquarters of the Watson-Stillman Press Division, Farrel-Birmingham Company, Inc., will be located at the company's modern plant in Rochester, New York.

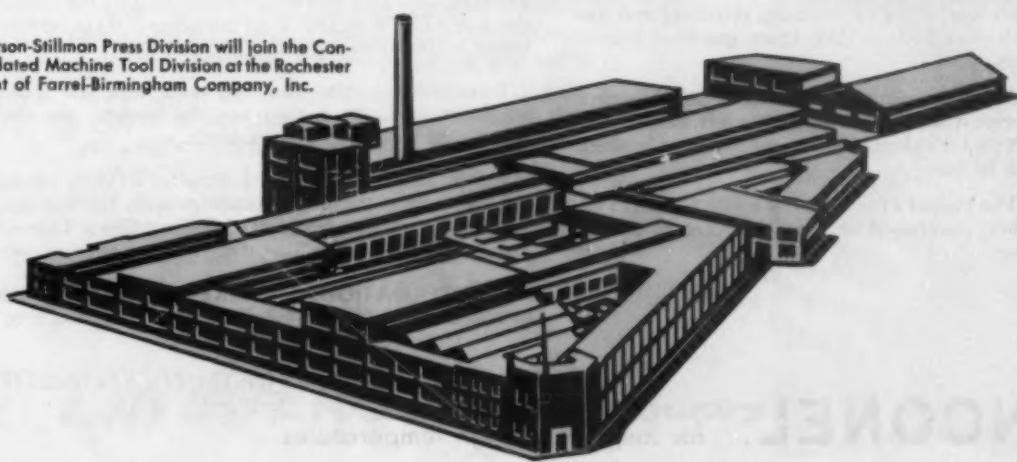
One of the finest, large machine-tool building facilities in the country, the Rochester plant has 10 acres of plant floor space and 21 acres of yard and open storage; complete, modern machine shops with over 50,000 square feet of erecting space; and spacious office facilities.

Manufacture of Watson-Stillman extrusion presses will be concentrated at the Rochester and Buffalo plants. With our headquarters closer to our manufacturing sources, you are assured of materially improved service in the future.

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WATSON-STILLMAN®

Watson-Stillman Press Division will join the Consolidated Machine Tool Division at the Rochester plant of Farrel-Birmingham Company, Inc.



WS-40

*Outlasts former
baskets
four to one...*



Wrought Inconel carbo-nitriding basket still in use after 29 months

This Inconel* nickel-chromium alloy basket is built by Rolock, Inc. for the Progressive Metal Treating Co., Bridgeport, Conn.

Progressive uses it for carburizing, nitriding and annealing small steel parts in their Ipsen gas-fired, batch-type furnaces.

After 29 months of continuous heat-treating service it *still* has plenty of life left, despite the fact that it's already outlasted previous baskets four to one.

The basket's twin has done just as well. Ten others, purchased later are expected to do the same.

Inconel alloy contributes four ways to long life

In this instance, Inconel alloy overcomes (1) early weld failures; (2) excessive oxidation; (3) the thermal shock of 1750°F to 150°F oil quenches; (4) progressive losses in initial strength due to corrosion.

Inconel alloy also contributes a high strength-to-weight ratio. Light as they are, the baskets can easily handle the 340-pound work loads.

For information on other successful ways to increase the life of heat-treating equipment with Inconel alloy, write for the Inco booklet, "Keeping Costs Down as Temperatures Go Up."

*Registered trademark

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INCONEL . . . for long life at high temperatures

If you apply heat to
aluminum **LINDBERG**
can show you the
better way

Lindberg-Fisher electric resistance melting and holding furnace with Lindberg Autoladle automatic pump.

Heat and aluminum have been Lindberg's twin babies for many years. If the manufacture of your product requires the application of heat to aluminum anywhere along the line we can help you do the job better. For years our engineering and research staff has been creating improved methods and developing more efficient equipment in this field.

Most recent development is the Autoladle (we call it "Little Joe"), the first practical automatic aluminum ladling unit yet devised. Used with Lindberg melting and holding furnaces "Little Joe" (shown at the right) makes automatic casting of aluminum fast, dependable and economical.

Lindberg's Melting Furnace Division makes a wide variety of melting and holding furnaces for aluminum, brass, bronze, tin, zinc, lead and other non-ferrous metals. These include aluminum induction, nose-pouring crucibles, electric resistance holding furnaces and big reverbs. For foundry, permanent mold or die-casting plant, independent or captive, there are Lindberg melting and holding furnaces to fit your requirements. If your problem in this field needs a special solution Lindberg's design staff can find it. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality, or write Lindberg-Fisher Division, Lindberg Engineering Company, 2450 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.



LINDBERG heat for industry

BRIDGEPORT BRASS COMPANY

Welds Aluminum Tubing at speeds up to

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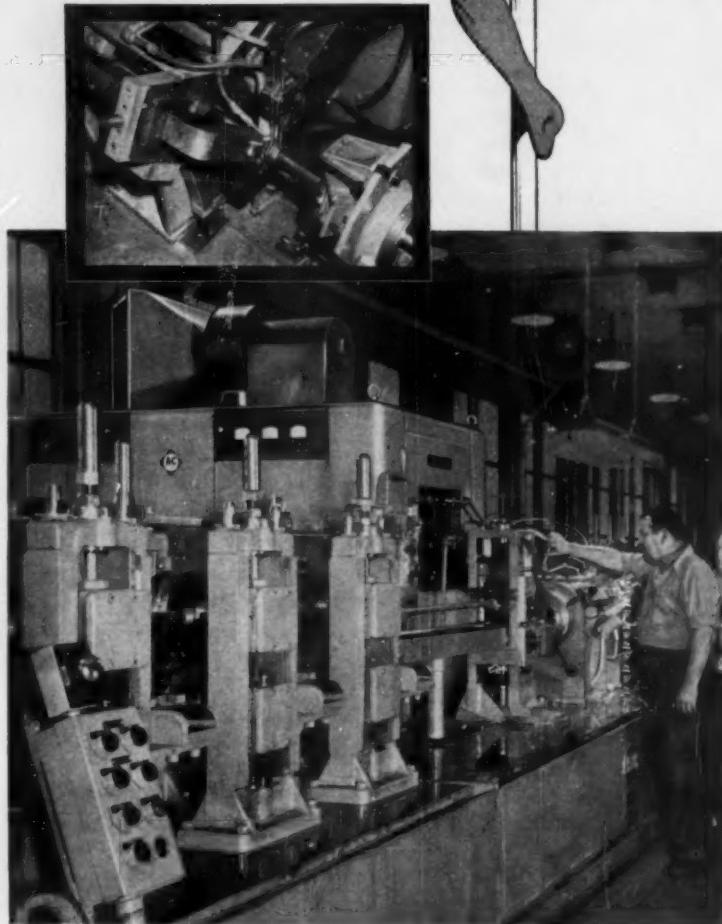


MODERN hi frequency and the Allis-Chalmers induction heater solved an important production problem and gave Bridgeport Brass tremendous welding speed. Because aluminum has an abrupt melting point and a tendency to buckle, conventional arc welding yielded but a few feet per minute. By confining heat to a thin surface layer at the contacting edges of the formed tubing, Allis-Chalmers induction heating produced amazingly good results where previous methods failed.

Why Allis-Chalmers

Allis-Chalmers enhances induction heating's inherent speed with properly designed work handling equipment. An automatic timer and output controls, standard on Allis-Chalmers units, promote precision operation. Extensive laboratory facilities, unparalleled application experience, factory supervised installation and service assure complete dependability.

If you braze, solder, harden, anneal or heat for forging or melting, it will pay you to get all the facts on Allis-Chalmers induction heaters. See your nearby Allis-Chalmers representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.



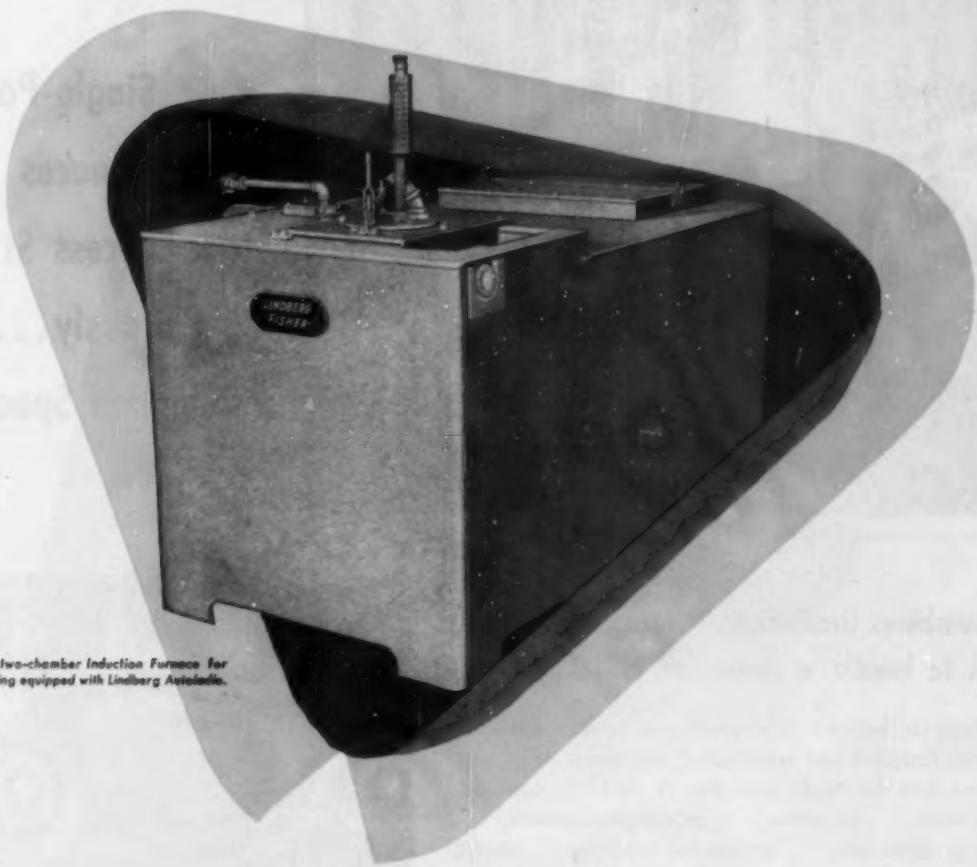
Heart of Bridgeport's integrated mill is a 50-kw Allis-Chalmers induction heater. Coil is interchangeable to accommodate various tube sizes.



A-5456

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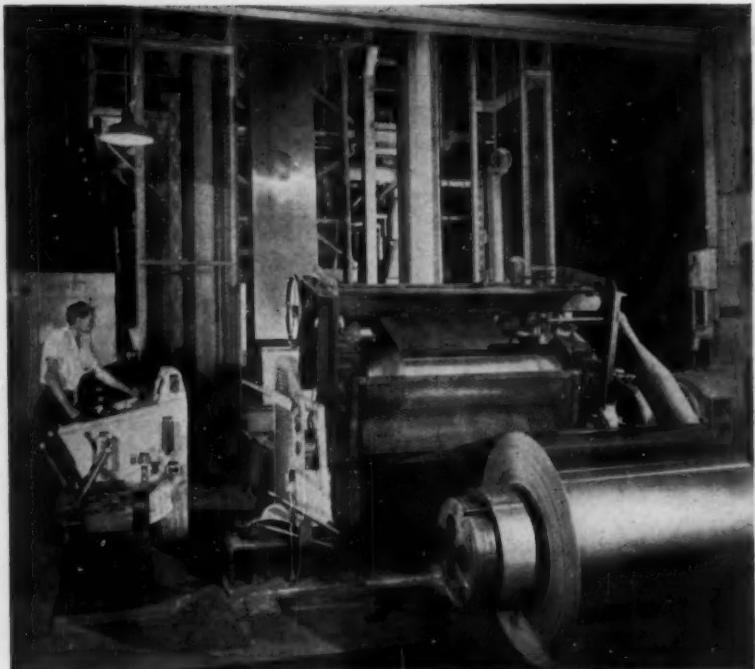


Lindberg-Fisher two-chamber Induction Furnace for melting and holding equipped with Lindberg Autoleads.

Do you die-cast aluminum? Then take Lindberg's famous two-chamber induction melting and holding furnace, add "Little Joe" Lindberg's new automatic pump, and you'll have the most efficient automatic combination anywhere. The Lindberg-Fisher two-chamber furnace *melts* in one chamber, *holds* metal at precisely the right temperature in the other chamber, and "Little Joe" automatically delivers exactly the right size shot to the casting machine. With this combination all handling of molten metal is eliminated, perfect control of metal temperatures and shot size is maintained, and all automatically. For safer, more economical, more precise handling of aluminum or any non-ferrous metals or alloys better see Lindberg. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality, or write Lindberg-Fisher Division, Lindberg Engineering Company, 2450 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.



LINDBERG heat for industry



Tin plate continuously bright-annealed in direct gas-fired vertical one-pass Selas furnace.

26 Single-Pass Selas Furnaces Heat-Process Strip Continuously... at Production Speeds

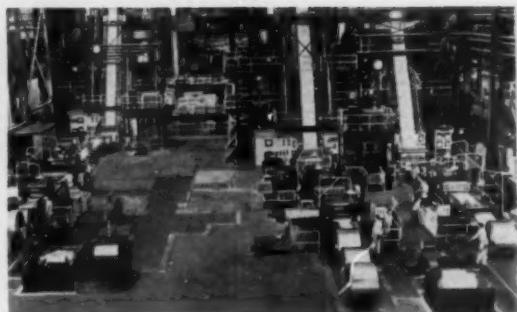
Selas combines Gradiation® Heating with process control to handle a variety of mill operations

Throughout the nation's metal-producing industry, Selas has pioneered, designed and constructed single-pass strip heat-processing lines for bright annealing of steel . . . annealing stainless steel . . . tin reflow . . . galvanizing-annealing . . . preheat for galvanizing . . . preheat for annealing . . . bluing . . . special coatings . . . brass annealing . . .

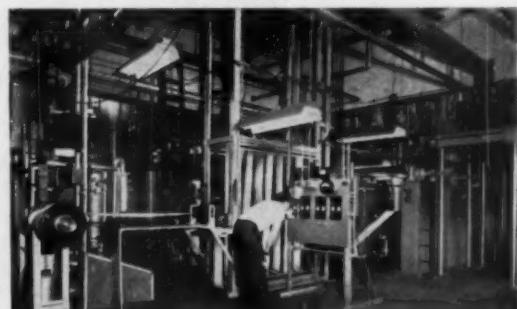
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- Compact single-pass design saves valuable floor space . . . avoids rolls in heated section, eliminating accompanying maintenance and product quality difficulties.
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*Our engineers will be glad to discuss how Selas Gradiation methods can be tailored to your strip heat-processing needs.
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Annealing and galvanizing strip 48" wide is a high-speed, single-pass, continuous operation with Selas Gradiation heating.



Control panel governs temperature, strip speed, gas combustion and atmosphere composition in this Selas annealing installation.

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*Lindberg Cyclone batch type
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heat for industry



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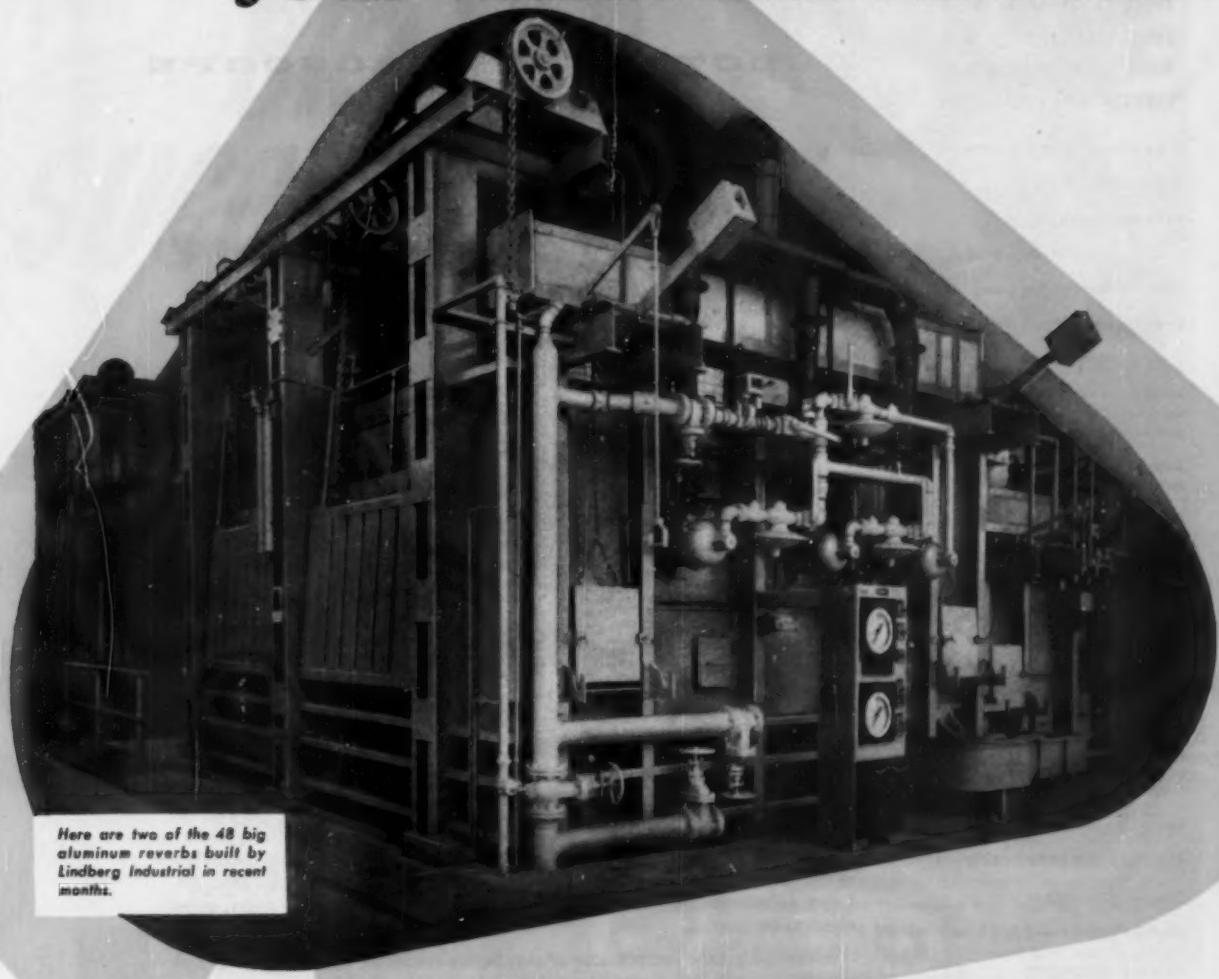
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ELECTROCHEMICALS DEPARTMENT
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Even if it's as big as a house...

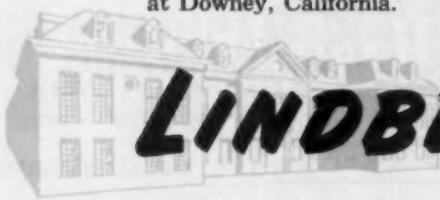
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Whatever your plant needs for any application of heat to industry Lindberg will field-install it for you. A big one like the big reverb illustrated or a dozen of them, or a complete "turn-key" job of smaller units. We offer a complete service from design and engineering through actual installation including all the construction needed to fit the new equipment into your production processes.

The safest way to be sure that you have the right answer for any field-erected application of heat to industry is to talk it over with the most widely experienced experts you can find. We believe we have them here at Lindberg. Our business is concerned only with the development of industrial heating equipment and we design and manufacture the most complete line in the field; heat treating furnaces, melting furnaces, high frequency units, ceramic kilns; electric or fuel-fired, built in your own plant. Get in touch with Lindberg Industrial Corporation, 2321 West Hubbard Street, Chicago 12, Illinois, or your local Lindberg Field Representative. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.



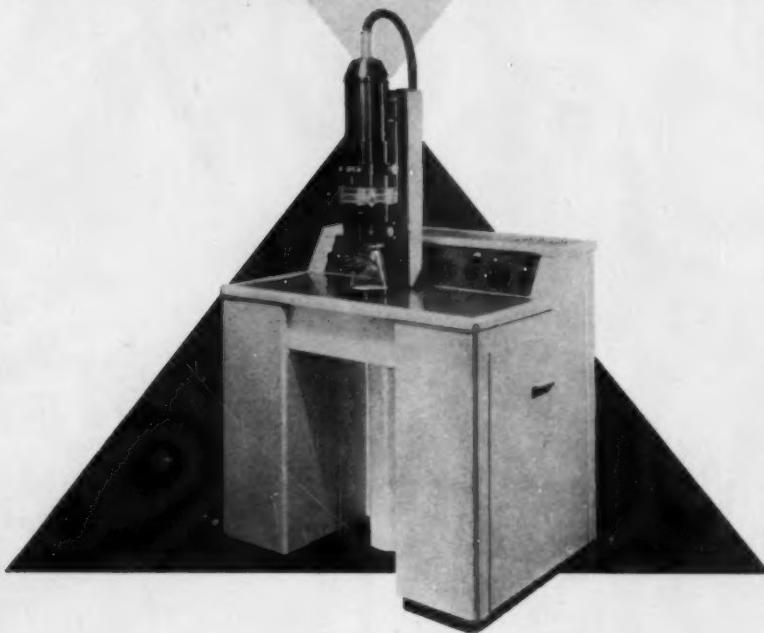
LINDBERG heat for industry

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Handles for the gold-plated (left) and standard "Heavy" (center) Gillette safety razors are made from Anaconda leaded commercial bronze special-shape seamless tube, .4525" O.D., .371" I.D. "Regular" model (right) is of commercial bronze .395" O.D., .324" I.D.

Gillette shaves costs with Anaconda special-shape tubes

The problem: The Gillette Safety Razor Company, Boston, Mass., formerly used drawn shells for the handles of its famous line of razors. Press-fit assembly of components called for very close tolerances and suppliers of the drawn shell had difficulty in controlling the dimensions to the accuracy required. Rejects and production delays were becoming a costly problem to Gillette, and there was also excessive waste of material in trimming the shells after the knurling, grooving and rolling operations.

The solution: American Brass Company representatives suggested the use of special-shape (fluted) tubes to meet the tolerances required—in alloys suitable for the machining operations. Gillette tried the idea and now uses Anaconda special-shape tubes for handles of three models.

Long lengths of the tube are fed into high-speed, multiple-spindle machines which automatically convert the tube to razor handles ready for the plating room. Production is greatly increased, rejects and waste material are reduced to a minimum, and the uniformity of the handles simplifies assembly. Most important of all to the Gillette Safety Razor Company is the improved quality of the finished product.

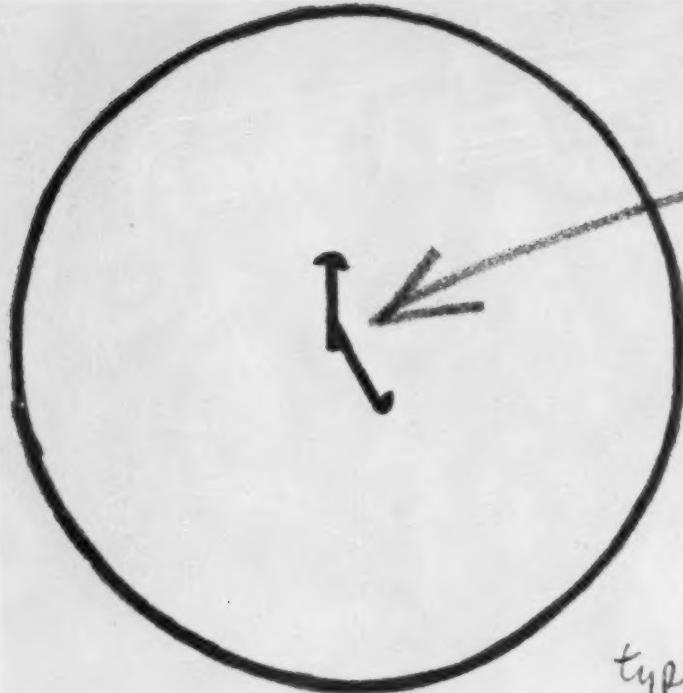
Save Material and Production Costs: Special-shape seamless tubes—of copper, copper alloys or aluminum—in standard lengths, or cut to specified lengths, can save several steps in arriving at a finished product. The American Brass Company's French Small Tube Division are specialists in producing small tubes (up to $\frac{3}{4}$ " O.D.) of special design and, in addition to maintaining a wide range of stock dies, are ready to cooperate fully in the development of new shapes to meet specific requirements.

For Action: Contact our nearest District Sales Office or send a sample, drawing or description, estimated quantity, kind of metal required and other pertinent data to: The American Brass Company, French Small Tube Division, Waterbury 20, Conn.

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SPECIAL-SHAPE TUBES IN LONG LENGTHS OR CUT UP—
IN COPPER, BRASS, BRONZE, NICKEL SILVER, ALUMINUM



In use, pressure is concentrated on center section of die

typical extrusion die

MEL-TROL

Until now, it's never been possible to look at an alloy bar or disc and be sure its center is as sound as its surface. Sometimes centerline weakness won't show even in a cross section. But it will show in rejects, breakage, rapid wear. The extrusion die illustrated is just one example.

High alloy or high carbon steel bars and discs made by conventional steelmaking practice are subject to poor toughness and erratic properties at the core. The cause is inhomogeneity—segregation, porosity, weakness—that occurs in the ingot while it is freezing.

Composition of the steel, purity, pouring temperature and ingot mold design all affect core quality. Core defects cannot be entirely eliminated by rolling and processing of mill shapes. They remain in the core of the

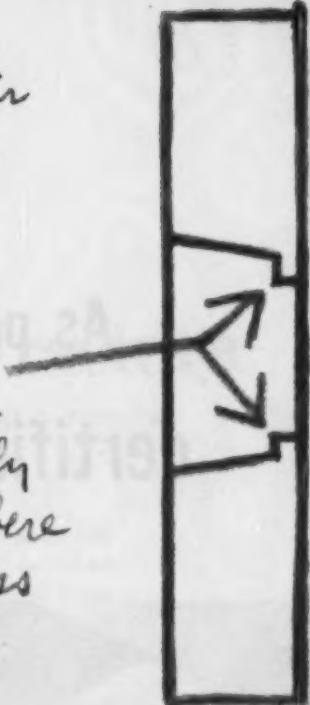
bar, and may vary from major defects such as internal cracks, porosity and center segregation to subtle differences in mechanical properties and service behavior between core and surface material which are virtually undetectable before machining or before a part fails in service.

The Mel-Trol process eliminates the problems of inhomogeneity by eliminating their causes.

Mel-Trol is an organized system of extra time, extra care, extra effort—perfecting the steelmaking process to its very greatest efficiency.

Quality control begins with scrap analysis, follows through the melt, casting the ingot, through rolling, annealing—all the mill processes that prepare Carpenter alloys for you—the user. Mel-Trol uses exclusive,

If bar from which die is made has any center porosity, segregation or weakness, die may break, because pressure is centered where these faults concentrate. That is why Mel-Trol alloys are proving superior to regular steels for this highly demanding application. Mel-Trol alloys are uniformly strong at core. Strength is always where it's needed because the Mel-Trol process virtually eliminates possibility of centerline weakness.



enlarged side view section

...new metallurgical achievement that is producing uniformity never before available in specialty steels

Carpenter-developed quality control tools and procedures along with the most modern equipment commercially available.

Mel-Trol gets results because—every quality control tool and procedure used is used to its fullest capability—nothing less. A typical example: Fuel injection nozzles which are exhaustively tested after machining. When

the manufacturer switched to a Mel-Trol alloy, rejects dropped from an average of about 7 per 1,000 to only 2 in 90,000.

Ask the Carpenter representative who calls on you about Mel-Trol. A selection of superior tool and die steels and elevated temperature alloys produced by the Mel-Trol method is available now—from Carpenter.

Carpenter STEEL

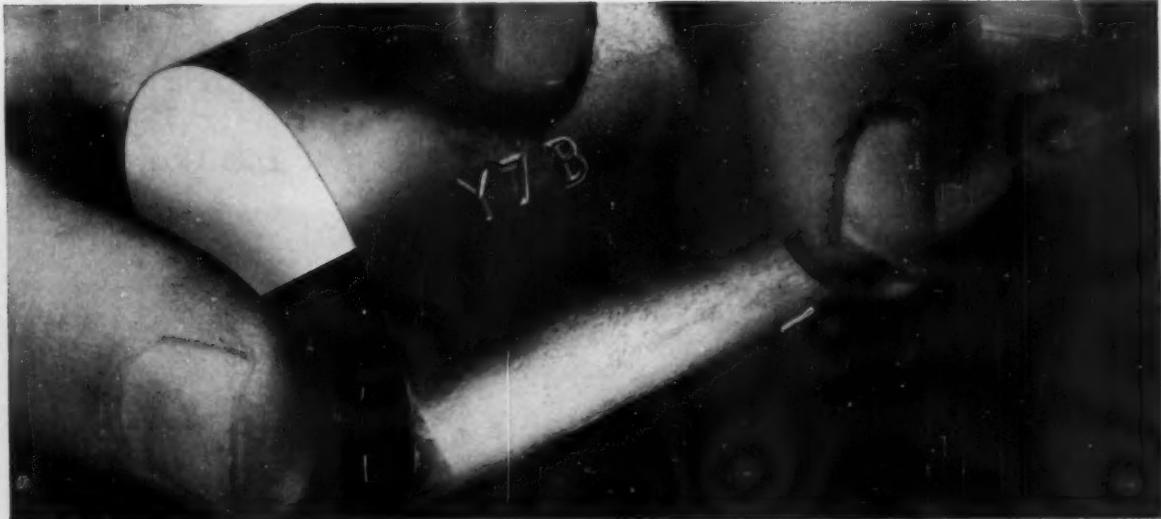
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1. **Heat analysis.** Not just the chemical range for the type of alloy, but the specific analysis

of the heat from which your steel was rolled.

2. **Tested Hardenability.** Not just the average hardenability for the alloy, but the actual Ryerson-tested hardenability for the particular heat . . . as quenched, and at three draw temperatures.

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Flow and Fracture

By EARL R. PARKER*

Today, designers and constructors of advanced machines and structures are often hampered by inadequate materials, a dilemma which can be solved only after acquiring knowledge about crystalline structure at an atomic level.

Progress in this line has been sufficient to devise substantial improvements in creep resistance. A ductile ceramic also seems a fairly early possibility.
(Q24, Q26, N general)

PRIOR TO ABOUT 1940, any equipment that could be designed could be built with existing materials. Since then, many machines and devices have been designed that cannot be built because of the lack of suitable constructional materials. Some examples of today's requirements are high-temperature semiconductors, structural materials high in strength and low in weight, and others that can withstand high tensile stresses at temperatures that would melt steel or the "superalloys".

Can the engineer rise to the challenge and produce the substances required by the atomic age? It appears that the answer must be "No", if past developmental methods and practices are followed. It is only necessary to review the progress made, for example, in gas turbine alloys. During the last 15 years millions and millions of dollars were spent on "high-temperature alloy development". To what avail? A few new alloys were formulated and marketed but the maximum operating temperature was barely raised 200° F. and at least half of this gain was due to better mechanical design and better quality control of the metallic parts.

I make so bold as to predict that lack of progress in this instance is in large part due to the same basic fault that retards progress in many other fields, namely, inadequate under-

standing of the basic physical processes which control the behavior of materials. Consequently, investigators were almost invariably forced to fall back on the empirical approach, trial and error — the same method used by metallurgists since prehistoric times.

Many of the advances in metallurgy for the last 150 years have been associated with chemical technology. Today, however, the situation is different. Metallurgy has reached the point where advancement depends upon our knowledge about solid-state physics. To cite a specific example, the transistor resulted from fundamental advances on the theoretical side; it produced a technological revolution in electronics. A similar example is the permanent magnet made of extremely fine magnetic powders, an "invention" due to theoretical advances which predicted from fundamental knowledge that such materials could actually exist. Clear-cut examples of this kind are limited in number at present but they are prototypes of those forthcoming within the next decade. Solid-state science will unquestionably play a major role in the *discovery or invention* of new materials.

*A digest of the Campbell Memorial Lecture, presented before the A.S.M. on Nov. 6, 1957. The lecturer is professor of metallurgy in University of California's department of engineering at Berkeley.

Another major contribution of solid-state science is an improved understanding of the behavior of existing materials, which will extend their use. While the sudden arrival of a new material is a dramatic event, tremendous technological advances may be expected to result merely from the systematic scientific analysis of materials and processes in current use. In fact, new materials and applications are most likely to occur as the byproducts of a deeper understanding of the behavior of old familiar metals, alloys and mixtures.

To appreciate the potential utility of solid-state science, it is necessary to remember that the properties of materials fall into two classes — those that are structure sensitive and those that are not. Since one of the metallurgist's functions is to control structure, he thus has potential control over one set of properties. About the other set, however, he can do nothing; he is powerless to change the elastic constants, density, specific heat, and heat of fusion or sublimation. On the other hand, tremendous variations are possible with ductility and strength.

I call upon the metallurgist to look forward into a new era of technology. In the decade following World War II, many new metals and metalloids became important. Germanium and high-purity silicon revolutionized the electronics industry; a whole new light-metal industry grew up around titanium; zirconium emerged from a laboratory curiosity to become a metal vital to the nuclear engineering program; uranium (almost unknown in 1940) and plutonium (an amazing man-made chemical element) formed the basis of atomic energy.

The big lesson to be learned from this roster of new metals is that a host of new materials, and many of them nonmetallic, is appearing on the scene. There are too many combinations of elements possible for us to investigate them all by trial and error methods. Even though actual test results will provide the background information necessary to select the new materials, intelligent application of basic principles is the only feasible means of attacking the problems ahead.

With this as a general introduction, perhaps necessary to an audience composed largely of men who are doing things with metals rather than inquiring into what makes them act the way they do, I should like to review in this Campbell Memorial Lecture for 1957 the concepts of flow and fracture that have slowly developed during the past two decades and to



Earl R. Parker,  Campbell Memorial Lecturer for 1957, is the author of more than 60 technical publications and a book entitled "Brittle Behavior of Engineering Structures". He has been a professor of metallurgy at University of California since 1945 and is vice-chairman of the Division of Mineral Technology. He received his metallurgical engineering degree from Colorado School of Mines in 1935 and was research metallurgist at the General Electric laboratories in Schenectady until 1944. Last year he was awarded the Mathewson Gold Medal of the A.I.M.E. for his research publications in that Society's journal.

show how these concepts can lead to the development of new or improved materials as well as to provide a better understanding of the behavior of those now in commercial use.

Dislocations

Prior to the conception of the dislocation theory, slip was known to take place on certain crystal planes and always in the direction of closest atomic packing. Theoretical calculations indicated that the yield strength of metallic crystals should be on the order of 10% of the shear modulus. However, real crystals were known to yield at stresses of only a few pounds per square inch. This observed weakness could not be explained if the crystals were really perfect — as assumed. Prior to 1930 there had been some speculation that crystals usually were

imperfect and there was rather convincing X-ray evidence that this was so. If crystals actually contained flaws, then their weakness might be explained on the basis of the stress concentrations existing around the defects. It was this sort of logic that led to the dislocation theory in 1934 by Taylor and Orowan. Taylor even developed a mathematical theory based upon interaction of the stress fields surrounding dislocations to explain how work hardening occurred and why.

The dislocation theory was elaborated slowly during the first decade of its existence. It was generally accepted as a theoretically satisfactory tool but there was no direct experimental evidence to confirm its validity. Undaunted, the theorists moved ahead, and by the latter part of the 1940's they were able to predict that certain events *should* occur. For example, "screw dislocations" *should* cause rapid growth of crystals from the vapor or liquid phase at a degree of supersaturation that could only cause very slow growth of "perfect" crystals. Again, theoretically, "edge dislocations" of like sign *should* arrange themselves above one another on parallel slip planes to form a small-angle sub-grain boundary and such a boundary *should* move when subjected to a shear stress. All of these predictions were confirmed by experiments in the early 1950's. During the intervening years, experimental techniques have improved at an almost unbelievable rate and today the modern electron microscope can watch individual dislocations move within metal crystals! Other experiments with transparent ionic crystals have further confirmed the existence of dislocations and the theoretical predictions of their behavior.

The newly developed experimental techniques and refined predictions of the theory have enabled us to understand how and why such phenomena occur as strain hardening, creep, yield point, solution hardening, precipitation hardening and grain size effects. Not quite matured but developing rapidly is an understanding of fracture phenomena, such as cleavage and ductile fracture, fatigue, intergranular cracking and stress-corrosion cracking.

Strain Hardening

What occurs within a metal to make it become harder and stronger when it is strained plastically? It now appears that the answer to this perennial question is at last in hand. Experiments with single metal crystals strained in simple shear have shown that dislocations moving

through a crystal lattice under the action of a shear stress are occasionally retarded by barriers encountered in their march. Various kinds of imperfections or discontinuities can act as barriers — for example, other dislocations, grain or subboundaries, and particles of a second phase.

Experiments have shown that when slip occurs on only one slip plane and in a single direction, the resulting strain hardening is due entirely to entanglement of dislocations at barriers. Dislocations tend to loop around these barriers, much the same as a rubber band can be stretched around a post, but the trapped dislocations are retarded and the stress must be increased before flow can continue. Technically speaking, the trapped dislocations produce a "back stress" in opposition to the applied stress; the applied stress must increase if flow is to continue. One important cause of work hardening is this "back stress".

There seems to be only one other major contribution to work hardening, namely, that due to the combination of two dislocations originating on different slip systems. When two such dislocations meet, they combine to form a new dislocation having a slip vector* in a direction different from that of either of the reacting dislocations and often in a direction where the lattice is unreceptive to slip. Combined dislocations form lattice discontinuities which moving dislocations can only penetrate with extreme difficulty. Thus, when slip occurs on more than one slip system, new barriers to moving dislocations are continuously being generated during the flow process and this phenomenon contributes to strain hardening.

When a metal is deformed at room temperature and then reheated to successively higher temperatures, several changes occur to relieve the acquired state of strain. Dislocation loops that have expanded outward from their source and have been held up by barriers tend to collapse, gradually becoming smaller and finally disappearing back into the source from whence they came. This process happens rather easily and quickly. It has little effect upon the hardness or strength of the metal but reduces internal stresses substantially and improves the electrical conductivity.

A second process that occurs is the annihilation of dislocations by the combination of pairs of opposite sign. This process generally requires the movement of the dislocations in the direction

*The magnitude and direction of the lattice displacement caused by slip.

perpendicular to the slip plane — a process known as "climb", which involves the condensation of vacancies or extra atoms on the dislocation line. The climb process is diffusion-controlled and hence the rate of climb versus temperature follows an exponential relationship.

A third phenomenon contributing to recovery is the formation of a substructure due to the collection of like dislocations in boundary walls, usually forming on surfaces perpendicular to the slip plane. As theory predicted, such an array constitutes a low-energy configuration of dislocations. Climb is also involved in sub-boundary formation and so this formation is also diffusion-controlled.

Creep

Ever since the phenomenon of creep was first discovered, attempts have been made to describe it in mathematical language. The first expressions were merely empirical equations formulated to fit the experimental results. In the early 1940's attempts were first made to formulate mathematical theories that were based on a physical picture of the creep process — specifically, on the basis of reaction-rate theory. In these theories, an unspecified "flow unit" was presumed to move through the lattice but was unable to move from one position to another without the assistance of thermal fluctuations.

During the past five years it has become increasingly clear from theory and experiment that creep is controlled by dislocation climb which in turn is controlled by self-diffusion. The activation energies found for the creep of almost all metals coincide with those for self-diffusion. Furthermore, simple single-crystal experiments have shown that the dislocations stopped by barriers at low temperatures are only temporarily retarded at creep temperatures. X-ray evidence has shown clearly that dislocation climb and substructure formation are associated with high-temperature creep. Thus in recent years experiments have shown that the rate-controlling process is dislocation climb and climb is necessary to permit dislocations to move past the barriers that stopped them.

Most of the theories formulated to date have been based upon the assumption that the *source* had to be thermally activated or that the *movement* through the lattice required thermal activation. Since the rate-controlling step is the escape of dislocations at trapping barriers, any theory based on those assumptions cannot be correct. Only within the past two years has a reasonable

theory been formulated with the assumption that climb is the rate-limiting step.

The shape of the creep curve has recently been explained and it is now possible to control the curve shape, changing it from its normal concave downward configuration to a straight line, or even reversing its direction of curvature. This can be done with simple procedures which produce subtle changes in the material's structure.

Solution Hardening

The concept of alloying to increase the strength of a metal originated during the Bronze Age. Exactly what happens within an alloy to make it harder and stronger than the base metal, however, is still a matter for speculation. It seems rather clear now that solution hardening is due to the interaction of solute atoms with dislocations. Just how and why these interactions occur is the problem. Experiments with steel have shown that the yield point (drop of beam in the tensile test) is due to dissolved carbon or nitrogen concentrated in dislocation walls or grain boundaries which stop the movement of dislocations. The shorter the distance between the pinned barriers, the higher the yield strength. It has been shown that the yield point of annealed medium-carbon structural steel can sometimes be increased by 25% without harm to other properties such as the Charpy V-notch transition temperature. The technique is to introduce a dislocation substructure within the ferrite grains and allow carbon or nitrogen to react with the dislocations in the sub-boundary network.

The mechanism of substitutional solution hardening has been more obscure. A number of theories have been advanced but none verified experimentally. Recent experiments with alloy single crystals indicate that the hardening process is like that for interstitial alloys — namely, it is due to the interaction of solute atoms with substructure boundaries. The evidence is clear that solution hardening is caused neither by the pinning or deactivation of the source, nor by retardation of dislocations as they move through the relatively perfect portions of the lattice.

Solution hardening has been shown to be structure sensitive, and so it is now clear that this phenomenon cannot be properly described by a simple general mathematical law.

Hardening in Two-Phase Systems

The cause of hardening in two-phase systems has not been elucidated to any significant extent principally because solution hardening has been

so puzzling. Plastic flow must still occur in a ductile matrix in which are dispersed hard brittle particles. Unless the flow and strain hardening processes that occur in a saturated solid solution (the matrix) could be clearly understood, it would obviously be impossible to understand how such a substance could flow when it contained a dispersed second phase. Now that an understanding of the mechanism of solution hardening seems to be at hand, one can attack the problem of plastic flow in a two-phase system with some assurance of success. This has not yet been done, however.

Fracture

There are a number of different kinds of fracture including cleavage, shear, fatigue, intergranular, and stress-corrosion. Fracture is known to be a two-stage process involving, first, nucleation of a crack, and second, growth of a crack. Theories describing growth processes are relatively simple to devise; indeed, a number have already been formulated. It is the crack nucleation that presents the real problem at present.

For example, how do dislocations act to form a crack nucleus in a ductile material failing by shear? Similar questions apply to all of the other types of fracture, and as yet there are no satisfactory answers. There is an encouraging note, however, because in current work a combination of theory and experiment is providing an understanding of how such crack nuclei can form in brittle cleavage fractures in steel at low temperatures. According to dislocation theory, groups of dislocations pile up at barriers such as grain boundaries and induce local tensile stresses which approach the theoretical cleavage strength of the material. Predictions based on this theory — for example, the effect of grain size — are in good agreement with experimental results, and it should not be very long before brittle cleavage behavior is well understood.

Recent work on the origin of fracture nuclei in fatigue has been very illuminating. Experiments have shown that, at least with some metals, cracks develop on the surface because flow occurs successively on two slip planes that intersect each other near a free surface. Periodic removal of the surface layers prolonged fatigue life indefinitely! In other experiments, single crystals of zinc were subjected to reversed cycles of simple shear. In a room-temperature test, with a strain amplitude of 1%, the crystal was unharmed even after three million cycles (6,000,000% accumulated plastic strain).

Thus, some of the conditions necessary to avoid or to cause fatigue have been disclosed. It seems that an understanding of the basic processes leading to fatigue will soon be forthcoming.

In regard to ductile shear-type fractures and stress-corrosion cracking, the theoretical picture is still vague and unsatisfactory. Both of these involve nucleation and growth of cracks but at present there is no acceptable picture of either how cracks get started or how they grow.

Nonmetallic Crystals

From the accumulated knowledge about flow and fracture processes, it seemed reasonable to conclude that certain nonmetallic materials, particularly cubic ionic crystals, should exhibit plastic properties like those normally associated with metals. Earlier work on sodium chloride and on silver chloride strongly supported this conclusion. A rather large fundamental program has recently been initiated to investigate the possibility of making certain refractory ceramic materials which would be ductile at room temperature. The early results have been encouraging. Many cubic ionic crystals have been tested and to date all have been found to be ductile or could be made so at 70° F.

The most encouraging results of all are those obtained with magnesium oxide. Single crystals could be bent through substantial angles without fracture at room temperature. Surface elongations up to 20% have been obtained in some of the bend tests. There is a good chance that a number of useful ductile ceramic materials will be developed within the next few years.

Conclusion

Perhaps enough has been said — even though in rather general terms — to indicate to the "practical" man that the "scientist" is working along lines which will build the foundations for new and useful materials of construction with unexampled properties.

Perhaps there is no reason to argue the point. A little reflection will indicate that the Edisonian "try everything" program is hopelessly inadequate in this day of rapid advance. The chance that such an approach would be worth what it costs is practically zero. I can assure any doubters that the achievements of the solid-state physicists during the last 15 years have been exceedingly encouraging, and I hope that this brief account of modern concepts of flow and fracture has illustrated that one point. We are at last learning something about why metals are so weak!

Direct Chill Casting of Large Aluminum Ingots

By A. T. TAYLOR
D. H. THOMPSON
and J. J. WEGNER*

Interrupted quenching is incorporated in the D.C. process to produce sound castings in sizes large enough to provide billets for huge forging and extrusion presses. A simple air blast device interrupts the flow of quenching water. (C5, N12; Al, 5-9)

MANY OF THE large presses which have been constructed for the heavy press program of the United States Air Force are now in production. The construction and operation of these massive extrusion and forging presses has aroused wide interest throughout the metal-producing and metal-consuming industries. This interest has been concerned predominantly with the construction features and operating characteristics of the presses. Often overlooked, however, is the extensive effort of the aluminum industry to establish the production techniques which will supply the outsize aluminum alloy billets required to feed these presses.

At the start of the heavy press program, the largest aluminum process ingots of high-strength alloy cast on a commercial basis had a maximum

transverse dimension of 12 to 14 in. It was foreseen that many of the forgings and extrusions to be made in the new mammoth presses would require considerably larger ingots. Unsolved problems associated with the casting of large ingots, therefore, presented a serious obstacle to the success of the program. Desirable goals for the aluminum industry would be the production of high-quality 32-in. diameter ingots in 7075 alloy and 2014 alloy.

Two years of development efforts by the Kaiser Aluminum & Chemical Corp. culminated in 1952 with the announcement that sound 32-in. diameter process ingots could be cast in 7075 alloy using a modification of the direct chill process. This modification employs the concept of an interrupted quench during the casting process. The interrupted quench reduces the rate and magnitude of stress build-up within the ingot, and thereby substantially eliminates the cracking problems which had previously made the routine casting of massive

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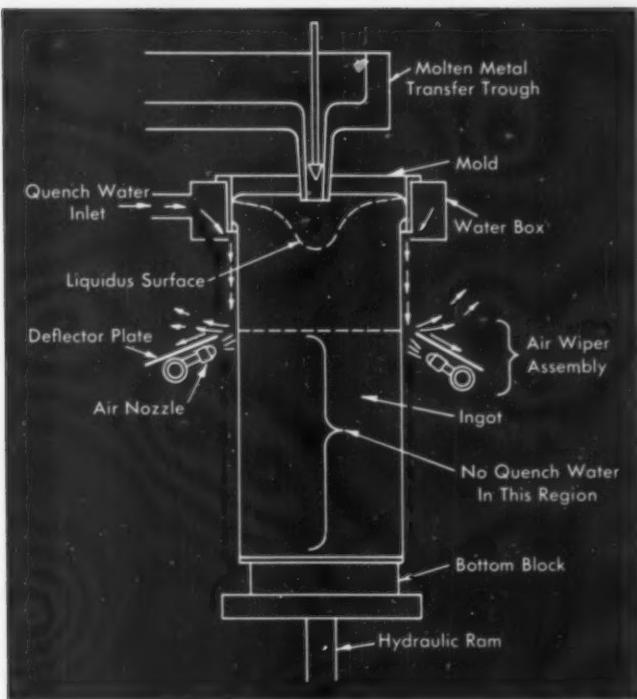


Fig. 1 — Direct Chill Casting Unit. Black arrows show course of quenching water in conventional process. White arrows show interruption of quench by air wiper

aluminum ingot in high-strength alloys an impossibility.

D.C. Casting Process

The D.C. (direct chill) casting process is the method used today to produce essentially all of the commercial aluminum ingots for subsequent processing by rolling, forging and extrusion. Developed by W. T. Ennor prior to 1940, the process has the advantage of producing a fine-grained structure with minimum segregation. High production rates are obtainable, and the process is adaptable to semicontinuous or continuous production. In a conventional D.C. casting unit the principal parts, as shown in Fig. 1, are a water-cooled mold open at both ends, a bottom block with lowering mechanism, and provisions for projecting quench water directly on the ingot periphery during casting.

To start the cast, the mold is closed at the lower end by a bottom block and molten metal is poured into this cavity. When the metal has solidified sufficiently to form a shell, the bottom block and embryo ingot are lowered at a controlled rate and direct chill casting is in process.

The heat contained in the molten metal, which is continuously added to the mold, is extracted by the mold cooling water, and most particularly, by the quenching action of the water sprays which impinge directly upon the ingot and flow downward over the entire ingot surface, as shown by the black arrows in Fig. 1.

Influence of Aluminum Alloy

The problems associated with D.C. casting have to do with both the alloy being cast, and the shape and size of the ingot cross section. Before 1952 the routine casting of process ingots of large cross section was impractical in stress-sensitive aluminum alloys — for example 7075 alloy. In this type of alloy the principal obstacles to the production of sound ingots are the wide temperature range of solidification and the tendency toward hot shortness.

Experience has shown that 7075 alloy, which has one of the widest solidification ranges, is the most difficult alloy to cast into sound process ingots. It is commonly considered that if a sound ingot of a particular shape and size can be cast in 7075 alloy, it is castable in other alloys commonly produced in this form.

Influence of Ingot Section Size

Rectangular ingots, intended for rolling into sheet and plate, have been cast in sections 12 in. thick and 48 in. wide, and individual ingots may weigh 6000 lb., although the weight depends on the capacity of the metal supply and the ingot length. Round and square 7075 aluminum alloy ingots with a principal transverse dimension much over 12 in. have not been cast until recently, although sound 2024 alloy ingots have been cast in sections as large as 16 in. in diameter. Other major aluminum producers have reported moderately successful casting of 32-in. diameter ingots in 2014 alloy but no details are available regarding the quality of the ingots produced.

The question then arises — what is a large ingot? The answer is related to the size and shape of the section and to the particular aluminum alloy being cast. In 7075 alloy, any ingot with the shortest transverse dimension greater

than about 12 in. is generally termed a "large" ingot. From the standpoint of tendency to crack, round ingots are more difficult to cast than rectangular ingots of equivalent cross section.

During D.C. casting, the thermal contraction of the metal generates a complex stress pattern within the ingot, which is a function of the ingot size and shape (round, square or rectangular). The larger the ingot—that is, the greater the transverse dimensions—the larger are the stresses. The stress pattern will also be affected by casting variables such as the ingot lowering rate and the flow rate of the quench water.

As the ingot lengthens, the stress pattern at

casting process, a sound 11 × 44-in. rectangular ingot can be cast in 7075 alloy, but the casting of a 15 × 60-in. rectangular ingot in the same alloy would be uneconomic due to excessive cracking.

Development of the Air Wiper

The solution to the cracking problem was basically the use of interrupted quenching during the casting process. It was realized that there was no practical method to increase the strength of the metal as it left the mold, but, by using an interrupted quench, it might be possible to reduce the build-up of internal stress caused

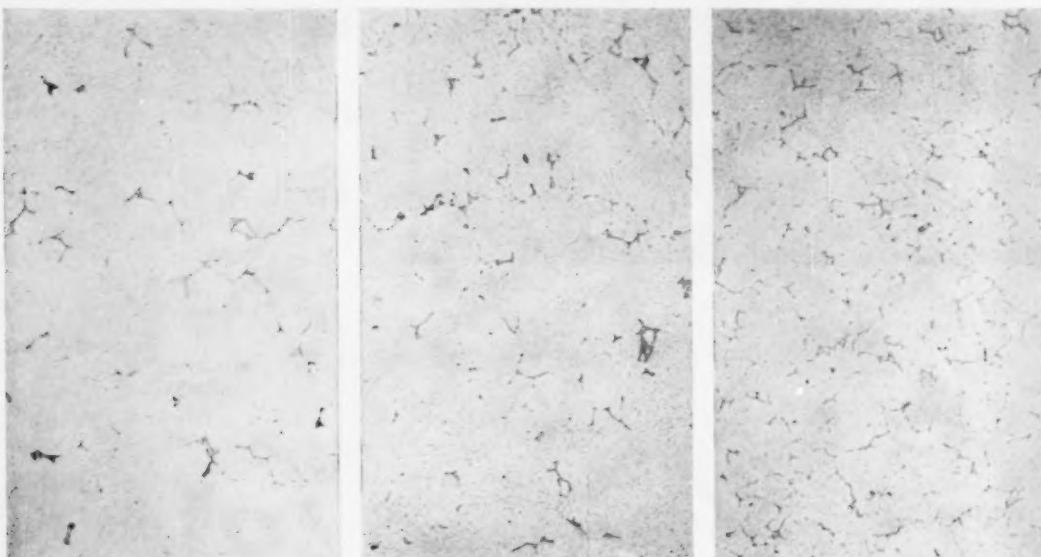


Fig. 2—Samples From Transverse Section of 32-In. Diameter 7075 Aluminum Alloy Ingot. From left, center of ingot, midradius and edge.

Ingot was given homogenizing treatment, and intergranular constituents reprecipitate as ingot is cooled. Etched in 0.5% HF. 100 ×

a particular transverse location changes continuously as a result of the progressive contraction of the metal due to continuous application of the quench water. Unit stresses increase continuously. At the same time, however, the metal at this transverse location becomes stronger as its temperature decreases. When, at any point, the unit stress exceeds the ultimate strength of the metal, the ingot cracks.

When casting 7075 alloy ingots, industrial experience has established that the dividing line at which the generated stress frequently exceeds the strength of the metal occurs in ingots which have a shortest transverse dimension greater than 12 to 14 in. Thus, using the conventional D.C.

by thermal contraction of the metal as it cooled. This was done by means of an air blast. As shown in Fig. 1, the nozzle assembly directs the air blast toward the ingot surface, thereby "wiping" it free of quench water.

In the Kaiser research department this technique was first shown to be practical for the production of high-quality 18-in. square ingots in 7075 alloy. Eventually the original goal was attained—sound 32-in. diameter and 24-in. square ingots of 7075, 2024 and 2014 alloys.

Concurrent with this work, other development programs were overcoming specific problems which adversely affect the quality of aluminum ingots. Gas porosity and inclusions were mate-

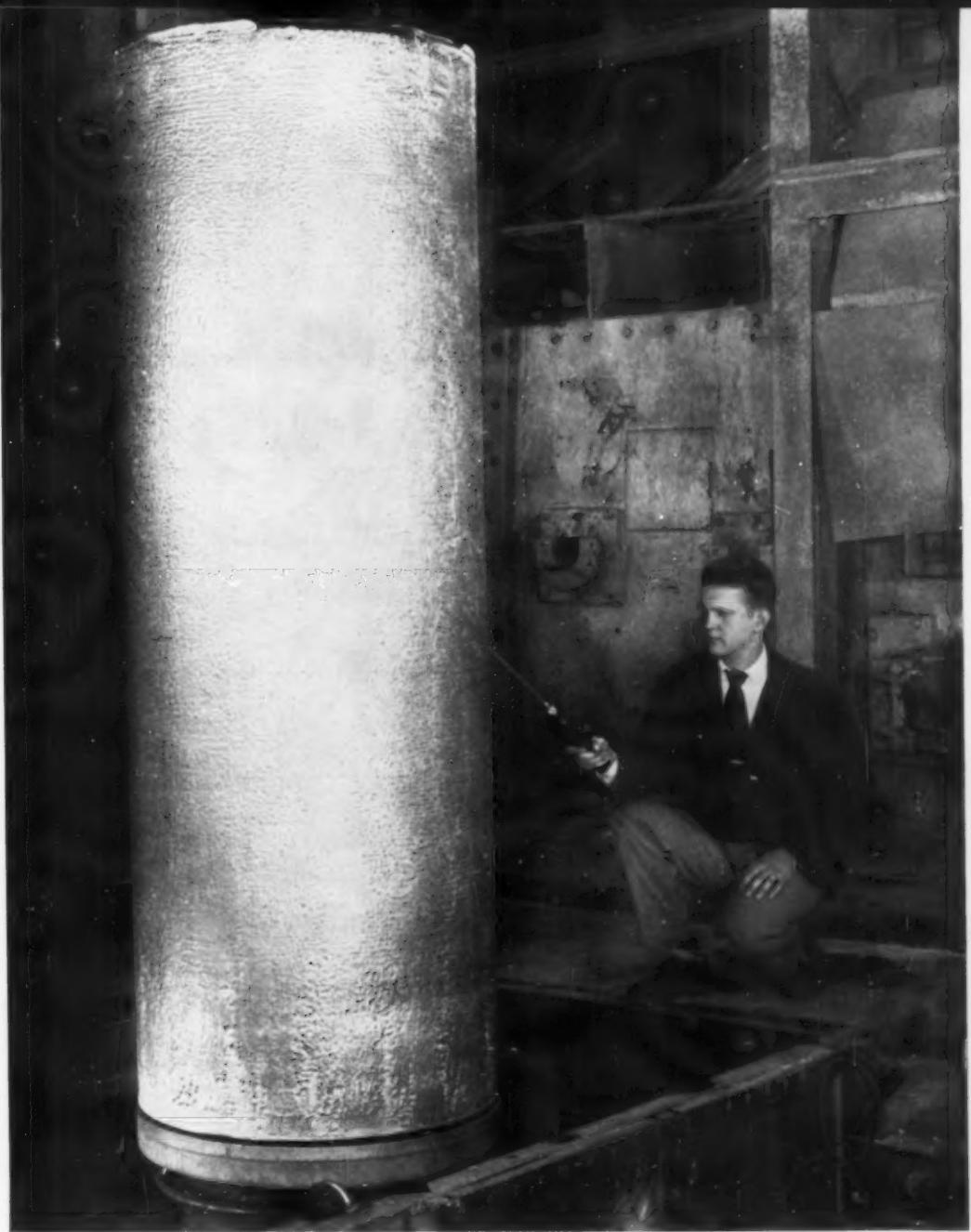


Fig. 3 - A 32-In. Diameter 7075 Alloy Ingot Immediately After Casting

rially reduced or eliminated by improved metal cleaning and degassing practices. Since these procedures are applicable to the casting of all ingot sizes, the improvement in the quality of both ingot and fabricated product can be considered a major achievement by itself.

Micrographs of as-cast sections from 32-in. diameter 7075 alloy ingots are shown in Fig. 2. The uniform grain size and absence of porosity

are evident. Figure 3 shows a 32-in. diameter 7075 alloy ingot immediately after casting. The over-all quality is excellent.

Air Wiper Design

The clearance between the ingot emerging from the mold and the air nozzles should be from $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. Larger distances would obviously require more air to remove water

Fig. 4 – Isotherms in Top Portion of 18-In. Square 2014 Alloy Ingots Cast Under Identical Conditions Except Use of the Air Wiper

completely and smaller distances might result in interference between the air nozzle assembly (air wiper) and the descending ingot. The elevation angle of the air nozzles with respect to a horizontal plane normal to the ingot face should be between 20 and 50°.

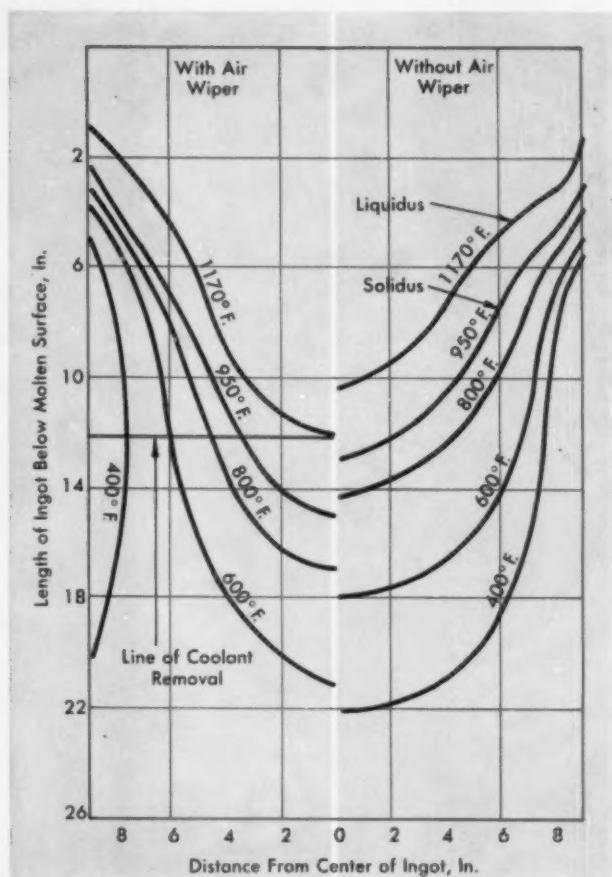
The major variable involved is the length of ingot sprayed with water before wiping. This distance is related to the minimum transverse dimension of the ingot, varying between one eighth and one half. Thus, for a 32-in. diameter ingot, length of coolant application is 4 to 16 in. It is somewhat dependent upon the particular alloy type – less stress-sensitive alloys can withstand a more severe quench.

Interrupted quenching also has other favorable aspects. A major problem in the casting of square or rectangular ingots has been cracking at the corners as a consequence of stress build-up resulting from over-chilling. At corner locations, the metal is cooled from two surfaces, whereas the metal midway along the face of the ingot is predominantly quenched from one direction only.

To overcome this corner overchilling defect the length of coolant application at the ingot corners is reduced by proper vertical positioning of the air wiper nozzles. As a result the corners are quenched less severely and corner cracking is eliminated.

Influence on Molten Metal Crater

To avoid shrinkage cracks it is generally believed that a relatively flat, shallow crater of molten metal is desirable. Temperature measurements made during the casting of an ingot indicated that the interrupted quench tends to produce a deeper crater. This is illustrated in Fig. 4 which shows the isotherms in the top portion of two 18-in. square, 2014 alloy ingots. Casting conditions were identical, except for quenching – continuous in the right-hand plot and interrupted at left. These data indicate that



the internal conditions produced by the use of the wiper are conducive to a deeper crater and a stronger tendency toward shrinkage porosity. However, it has been possible to adjust other casting conditions to compensate for this tendency and produce sound ingots.

It is entirely possible that ingots with a minimum transverse dimension much larger than 32 in. can be cast using the principle of the interrupted quench. However, the commercial need for larger aluminum process ingots has not appeared to date.

Other means of reducing the quenching rate of ingots can be visualized as alternatives to a water removal system. For the present, however, this method appears most advantageous from the standpoint of versatility and economy. Consequently, the development of this modification of the classic direct chill process stands as a major advance in the field of casting aluminum process ingots.

Modern Heat Treatment Facilities

By DANIEL A. TULLOCK, JR.*

Heat treating equipment for hardening and coloring high-strength studs and bolts without damage to threads is installed in new building, a model of cleanliness, ventilation, light and elbow-room in the basement.
(J26n, J29, W27g, W12r, 1-2; ST)

IN 1955, when we decided to improve the heat treating facilities at the Holo-Krome Screw Corp. plant in Hartford, Conn., we had many objectives. To understand these objectives to be incorporated in any new installation, we should first describe our old methods. Although they resulted in a product of good quality, the conditions in the department left much to be desired.

For more than 25 years, we had been hardening socket screws in continuous furnaces of both the conveyer and reciprocating-hearth types. After the oil quench, the parts were centrifuged to remove the excess oil and then placed in batch tempering units of the rotary type. When the tempering cycle had been completed, the parts were again oil quenched and centrifuged before sending them to the packaging department.

Cap screws, set screws, socket-headed bolts and the like, heat treated in this manner, were delivered with a uniform black color which, in our industry, is an important factor. This, then, was a desirable result. Small nicks on the threads, accumulated during the nine times the parts were dropped in the process, plus the slow tumble in the rotary tempering furnace, were a constant source of trouble. These nicks, there-

fore, had to be eliminated or certainly minimized in any new installation. At the same time, a clean black finish had to be maintained.

It was obvious that the way to eliminate nicking would be to reduce handling. This could be done through automation, but in our opinion only through controlled automation. We therefore presented our problem to eight manufacturers of continuous heat treating equipment. In addition to data as to production rates, hardness and physical properties of the product — especially the surface layers — we not only told them the parts had to be a good, clean black, but also that the nicking had to be eliminated. Actually, we gave them all the latitude possible, for we told them we would be interested in any "dream unit" they might have, either on the drawing board or in their minds. Frankly, we were disappointed in the results, for each of the manufacturers, with one exception, quoted on the same type of continuous setup they have been manufacturing for the last 10 to 20 years. The exception was the American Gas Furnace Co. of Elizabeth, N. J., whose unit we ultimately purchased.

* Chief Metallurgist, Holo-Krome Screw Corp., Hartford, Conn.

Continuous Unit

Basically, this continuous hardening and tempering unit (shown in Fig. 1) consists of one of their No. 242 reciprocating-hearth furnaces in line with a new, and we believe quite novel, conveyer type of tempering unit. As originally installed, the charging end of the unit at the left of the illustration was equipped with a vibrating feed mechanism made by the Syntron Co. We have many such units in our plant, but for this application we replaced the mechanism with a 5-ft. shelf extending in front of the muffle hearth, supported on rollers, from which the work automatically works forward to the reciprocating hearth of the furnace. After being gently poured or placed on this muffle extension, the small parts proceed through the furnace at the proper rate for their size, and slide down a sealed chute pitched at 60° into the quench oil where they come to rest on a mesh conveyer.

Through this stage of the process, we insure an unchanged carbon content at the surface by introducing an atmosphere which is essentially nitrogen with low percentages of hydrogen and carbon monoxide. This is an exothermic gas from which carbon dioxide and water vapor have been removed. The nitrogen generator, manufactured by the Gas Atmospheres Corp. of

Cleveland, is equipped with a Cambridge hydrogen analyzer which records, controls and thus guarantees gas with constant chemistry.

The work, on being quenched, is raised on a flight conveyer to a chute where it again slides down onto the belt conveyer of the tempering unit. We feel that the American Gas Furnace Co. really came up with something when they designed this unit. The belt travels through a completely enclosed muffle; combustion gases never come in contact with the work. The belt travels through the muffle to the discharge end where it passes over an alloy roller, down a 60° slope, around another roller and then through a seal leg into a shallow tank full of soluble oil. (Naturally, the work leaves the belt at the end of the 60° slope.) This seal of soluble oil at the far end leaves only one opening to the atmosphere, namely the one at the charging end, and here, as can be seen in Fig. 1, the flight conveyer with its charge enters a hood extending downward to below the level of the furnace's hearth. Since oil is carried on the parts, the vaporizing oil creates a positive furnace pressure and thus no air infiltrates. The parts are therefore tempered in an oil vapor atmosphere and the resultant black finish is excellent.

After being tempered, the parts slide into a tank of soluble oil, are cooled and then conveyed

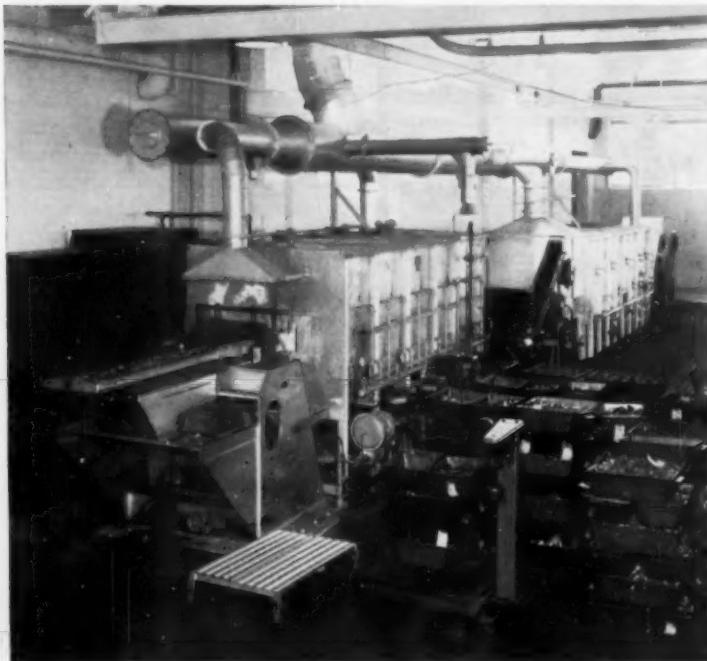


Fig. 1 - Hardening Furnace Has Long Prolongation of Reciprocating Hearth for Charging Small Work. Tempering furnace at rear operates with atmosphere of vaporized quenching oil. All handling equipment is especially designed to prevent severe impact which would mar precise finish

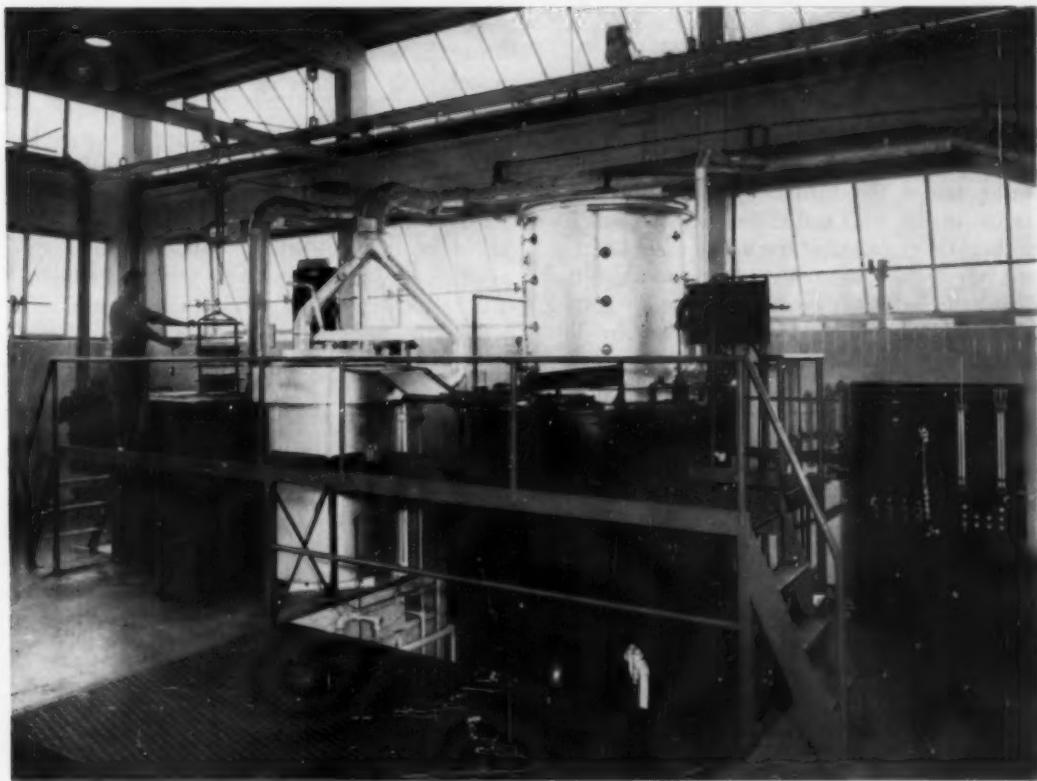


Fig. 2 — Large Screws, Studs and Bolts Are Jigged. Hardening furnace at right has entrance vestibule in front (dark portion). Fixture is lowered on elevator, moved toward rear, lifted into heating chamber (light portion above), lowered into quenching bath in bottom of unit, and then retraces steps to outside. Quenching oil remaining in socketed heads is sucked out by vacuum cleaner before fixture is put into drawing furnace (light-colored unit in center)

to a Syntron mechanism which removes the excess oil and deposits the parts in tote pans. When this new furnace was started up we used quench oil in this tank but soon found that the carry-out completely saturated the packages. This was undesirable for obvious reasons, yet we did not want to go back to a centrifuge; a vibrator did not remove sufficient oil. The decision was made to convert the tank so it could efficiently use soluble oil. It was therefore insulated and covered. In order to heat the oil to 160° F. we utilize a glass-lined domestic hot water heater and pump the soluble oil through the tank. It works very well, although it takes 36 hr. to bring the temperature up. This is of little consequence since we merely let the heater run over the week end. We are using a high-grade, rust inhibited soluble oil compounded for

us by the Swift Industrial Chemical Co. of Canton, Conn. The feeling here is that if a soluble oil is needed, we should use one that will pass on some benefit to the customer — which, in this instance, is a product that will resist rusting.

Unit for Larger Work

Our new heat treating department also had a definite need for a furnace to handle large-diameter and long lengths of cap screws. For the past several years, sales of these larger and longer screws have increased tremendously. We had previously sent the parts to a commercial heat treater, but this sometimes delayed deliveries, and now and then lots had to be rehardened.

Our choice was once again a unit especially designed and built by the American Gas Furnace Co. The furnace is the right hand unit in Fig. 2. The parts are suspended by their heads on alloy plates which in turn are supported on a rack. The operator and small overhead crane are handling one such rack with 1½-in. diameter cap screws in it. This rack would be transferred to the top of the unit at front right of Fig. 2,

lowered through the trap door on the top front of the forward section (the dark tank) to the platform of a hydraulic elevator. The elevator lowers its load to the oil level, which is at the trap (white piping) shown at the front of the unit at about floor level. The load is then swung under the furnace proper (the white portion to the rear) and raised into the bell for the heating cycle. After the appropriate heating time, the load is lowered straight down into the oil quench, then swung over under the exit hatch, raised by the elevator, and removed by the workman. The entire operation is done under atmosphere.

As these socket screws are removed from the hardening unit, each socket is filled with oil. The volume thus entrapped is considerable. How to remove this oil before tempering in our Lanly pit-type recirculating air furnace was a problem which was quite readily solved with a Tornado vacuum cleaner. Passing the nozzle over the heads of the screws quite effectively sucks out all of it.

A Clean, Light Working Place

So much for the new equipment installed in the new heat treating department at Holo-Krome. We had something other than product improvement in mind when all this was done. President W. C. Stauble feels that the worker is the most important consideration in the plant. The machines don't count for much without people to operate them efficiently. He therefore believes that everything should be done to lighten their tasks and improve their working environment, making it as pleasant as possible. This was a primary aim in the new addition to the heat treating department.

The walls in the new area are a light grey ceramic tile. The ceiling and mono-rails are painted yellow. This new area is about 6 ft. higher than the adjacent manufacturing buildings. Thus, the whole roof in this area is, in effect, a monitor with windows on all four sides. (One of the window openers can be seen in Fig. 2 above the pit hardening furnace.) On the lower level, there are windows on only two sides. All of them run the entire length of the room and each section is operated by one motor. During the very hot summer of 1956, this area was as pleasant to work in as any section of the factory.

In our older installations, the pit areas around the quench tanks were just a little larger than the tanks themselves. This resulted in almost

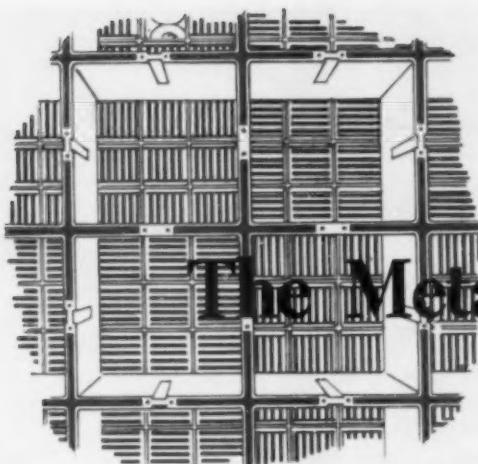
impossible conditions for maintenance and repair men. In the new addition, the pit is approximately half the area of the room and is 7 ft. deep. The quench tanks and furnace sections of the continuous line in Fig. 1 are supported by I-beams with steel grill-work floors around them. Blowers, pumps, and piping are all suspended from the same floor beams. Thus a man can stand naturally in the pit and work on any of the equipment. An additional advantage of hanging all the auxiliary equipment from the ironwork is that the pit floor can be mopped and hosed down. Pit walls and floor are also painted yellow. This pit is large enough to accommodate a second continuous line parallel to this first unit.

The storage tank for quench oil is located horizontally under the floor with a connection outside the building for filling from a tank wagon. Actually, we operate with this 5000-gallon tank and a 2000-gallon sump tank (the latter also located under the floor). Both tank-ends protrude into the pit 3 ft. with all piping connections on this end and a removable manhole on top. The main circulating pump and a stand-by pump are actually below the sump tank; therefore the suction side is always under pressure, which avoids all priming problems.

The oil is pumped from the sump through a Niagara evaporative cooler to the discharge chute of each hardening furnace. Each quench tank has an overflow weir at the end and thus the oil returns to the sump by gravity. When the oil level in the sump drops, due to dragout from the quench tanks, we merely start a small transfer pump and bring oil from the main storage tank to the sump tank. If the operator forgets to stop the pump, it will automatically stop when a pre-set level is reached. If it were necessary to empty a tank in an emergency, proper valving permits the main large-capacity circulating pump to transfer oil from the sump to the main storage tank.

Perhaps it should also be pointed out that the units shown in both illustrations are in operation. Because of the efficiency of the exhaust system installed on the equipment, there is never a wisp of smoke in the room even though smoke is really being produced, especially in the continuous tempering unit.

Thus the task set two years ago has been accomplished. We have given the workers a clean, healthful place to work in, the customer has benefited by getting a better product, and Holo-Krome has benefited by producing a better product at a lower cost per pound.



The Metallurgy of EBWR

By KARL F. SMITH*

Development of the first experimental boiling water reactor created several metallurgical problems not previously encountered in atomic energy utilization. In finding solutions, Argonne National Laboratory developed new alloys and new fabricating techniques. (W11p, T11, 17-7; U, Zr, ST, SS)

THE ARGONNE NATIONAL LABORATORY "went on" atomic power in December 1956. At that time, the experimental boiling water reactor reached full power level at the site of the laboratory, located near Lemont, Ill.

The plant produces 5000 kw. of electricity, which is enough to provide the laboratory with its own power requirements and to show that larger power plants can be built using the principle of steam generation within the reactor itself. In addition to this simplification, in which heat exchangers are eliminated, a bonus advantage of increased safety accrues from its self-regulatory nature. In EBWR, generation of too much steam automatically reduces activity of the reactor by reducing the amount of moderation in its core.

EBWR uses "light", or ordinary water in its operation, although future plans include some tests with heavy water. Water circulates in a closed cycle by gravity. After leaving the pressure vessel which houses the reactor, steam goes to a conventional steam purifier and then to the turbine, after which it is returned to the reactor as water through a condenser. A continuously operating ion-exchange systems keeps the water pure and to the right degree of alkalinity.

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Metallurgical Problems

Unusual conditions of irradiation and corrosion combine, as in other reactor plants, to present metallurgical problems. In turn, usual materials developed to meet these requirements result in further problems associated with the production, fabrication, and utilization of the new materials.

EBWR employs slightly enriched uranium (1.4% U²³⁵) in the fuel elements. Metallurgically, the degree of enrichment with an isotope is not too important, because the mechanical and thermal properties are the same for both. Differences in technique of handling arise from the degree of care necessary to conserve the rarer isotope and to keep its dust out of the surrounding atmosphere during operations because of its greater health hazard.

The fact that uranium needs to be used at all in reactor fuel elements is unfortunate. Like some people, uranium is difficult to live with, and difficult to be without. When used as plain alpha-rolled uranium, the heating and quenching effect on a microscopic scale produced by the neutrons in a reactor causes it to grow, warp, and squirm, so that the shape of the fuel element would soon be so distorted as to bear little resemblance to its original shape. Heat removal under these conditions would become inefficient

and spotty in the core assembly, allowing some parts to overheat and fail rapidly by melting or rupture of their protective cladding.

Beta quenching of uranium from the range 660 to 770° C. (1220 to 1420° F.) results in a more stable structure, but some residual instability plus grain coarsening effect leave this metal considerably short of being a completely desirable fuel material.

Another facet of the problem, that of corrosion, enters into the selection of alloys for the fuel elements. The EBWR was not designed to boil at atmospheric pressure, but at 600 psi, at which the associated temperatures are highly corrosive to many metals. The Zircaloy-2 cladding for the fuel element material will withstand these conditions, but if a small rupture should appear in the cladding, and if the fuel material were unalloyed uranium, the latter would rapidly corrode and be lost out of the small fissure. Uranium itself has very low corrosion resistance to pressurized water. The water would then become grossly contaminated with fission products of uranium, and the fuel element would be progressively destroyed. It was therefore necessary to pursue the additional goal of increased corrosion resistance in the search for a suitable alloy for the fuel material, so that at least a second line of defense could be set up against that eventuality.

In the search for alloying agents that would provide stability toward irradiation and better resistance to corrosion, the ternary alloys with zirconium and columbium* eventually survived an elimination contest and showed some promise.

The uranium-base alloy with 5% zirconium and 1½% columbium, when quenched from the gamma phase, does not retain gamma, but forms an acicular alpha structure, similar in appearance to martensite in steel. The structure is quite corrosion resistant to high-temperature water. However, tests in the materials testing reactor at the National Reactor Testing Station in Idaho have shown unsatisfactory results under irradiation for this particular structure.

When this same alloy is isothermally transformed in the temperature range 630 to 650° C., the resulting structure becomes alpha plus gamma, which has been shown to be quite stable under irradiation, but of limited corrosion resistance. That is, the corrosion resistance is better than that of unalloyed uranium, but not as good as the gamma-quenched structure.

*Referred to as niobium by chemists.

In an effort to have our pie and eat it too, compromises were tried in heat treatments, including the use of a gamma quench followed by an isothermal treatment. All these artifices were unsuccessful. Accordingly, the decision was made in favor of the material of greater irradiation stability, despite its only moderate corrosion resistance. As a consolation prize the rolling characteristics of the alloy turned out to be more compatible with the Zircaloy-2 cladding than were those of unalloyed uranium.

Fabrication of Fuel Elements

Following selection of the fuel alloy it was next necessary to resolve fabrication variables. Reactor designers specify thickness of cladding in accordance with the requirements of physics and the necessities of mechanical strength at service temperatures. A given limit on the ratio of structural material to fuel material, made necessary by neutron economy, sets an upper

Fig. 1 — Core Shell Is Lowered Into Pressure Vessel

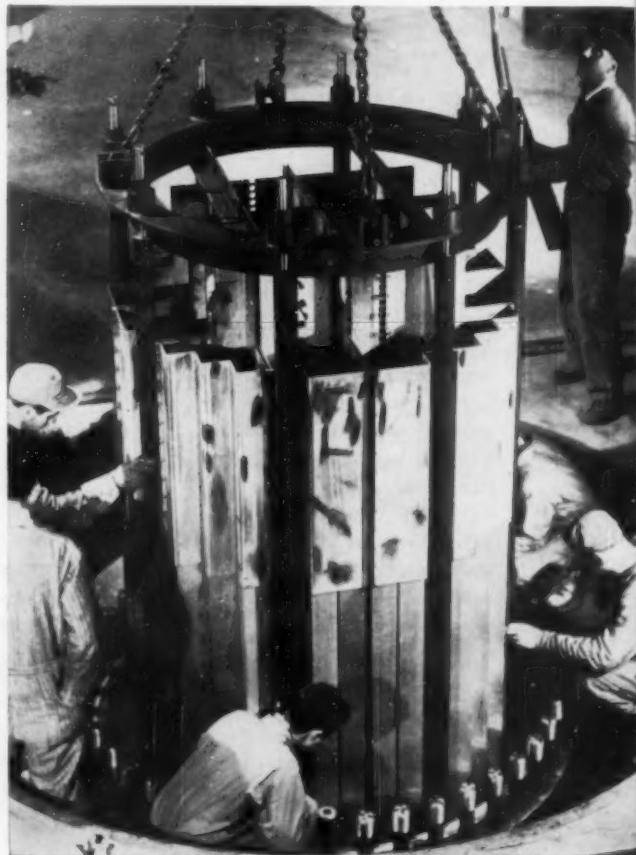




Fig. 2 - The Core Shell, Loaded With the Fuel Element Subassemblies, Is Put in Place. To prevent criticality, the core assembly must be made with the control materials in position

limit to the thickness of cladding which can be depended on to restrict a tendency to internal movement in the fuel material.

Translated to the fabrication process, this means that plate rolling tolerances must be so close that they approximate machining tolerances. For example, if the rolling temperature falls outside a certain narrow range, the core alloy tends to deform more or less easily than the cladding material, resulting in a disproportion of thickness which cannot be compensated for by machining, because of the thin layer of cladding involved. Furthermore, an optimum reduction sequence must be built into the mill by automatic means to insure uniform treatment for each plate. By radiographing each rolled plate, the core must be located with sufficient precision to finish machine the sides and ends.

Each plate was inspected for quality of bond between cladding and core by an ultrasonic recording method specially developed for the purpose. In addition, gross inclusions and porosity in the metal were readily spotted by this technique, a similar routine being applied to the original billets as well as to the finished plates.

An automatic welding device was designed and constructed for fastening six finished plates together, parallel to one another, in the manufacture of a subassembly for the core of the reactor. The number of these subassemblies necessary, together with the requirement of uniformity, made hand welding out of the question. By mechanical positioning, each weld which joined the flat side of a Zircaloy-2 side plate to the edge of a fuel element by the arc-spot method, was made according to a preset program of timing and current. The "arc-spot" method of welding plates into position works from the outside of the flat plates with fusion extending inward to the edge of the active plate. Spots are made, one at a time, with three electrodes on a carriage which contact consecutively and then move to a second lateral position before shifting to the next longitudinal position. By this arrangement, plates 1, 3 and 5 are welded in place and then the carriage shifts to weld plates 2, 4 and 6.

Predetermined value of the current was high as the arc was struck. This was followed by a reduction to about half current value to preheat the workpiece. At a certain stage the current again abruptly increased while the weld was made; then the arc was broken. With this machine approximately three subassemblies per hr. were manufactured from the fuel plates.

The Pressure Vessel

The pressure vessel of EBWR is 84-in. ID, weighs about 60 tons with internals in place, and is designed to withstand 800 psi.

Strength of the vessel is provided by the use of SA-212 fine-grained steel. This is a boiler steel with 65,000 to 70,000 psi. tensile strength, 35,000 psi. minimum yield strength and minimum elongation of 21%. Maximum composition limits of the steel are: carbon 0.28%, manganese 0.90%, phosphorus 0.035%, and sulphur 0.15 to 0.30%. All parts of the interior which are exposed to hot water or steam are clad with Type 304 stainless steel, because of its good corrosion resistance.

Neutron irradiation doesn't affect steel to any great extent. What it does do is harden it some, raise its tensile strength a little, lower its elonga-

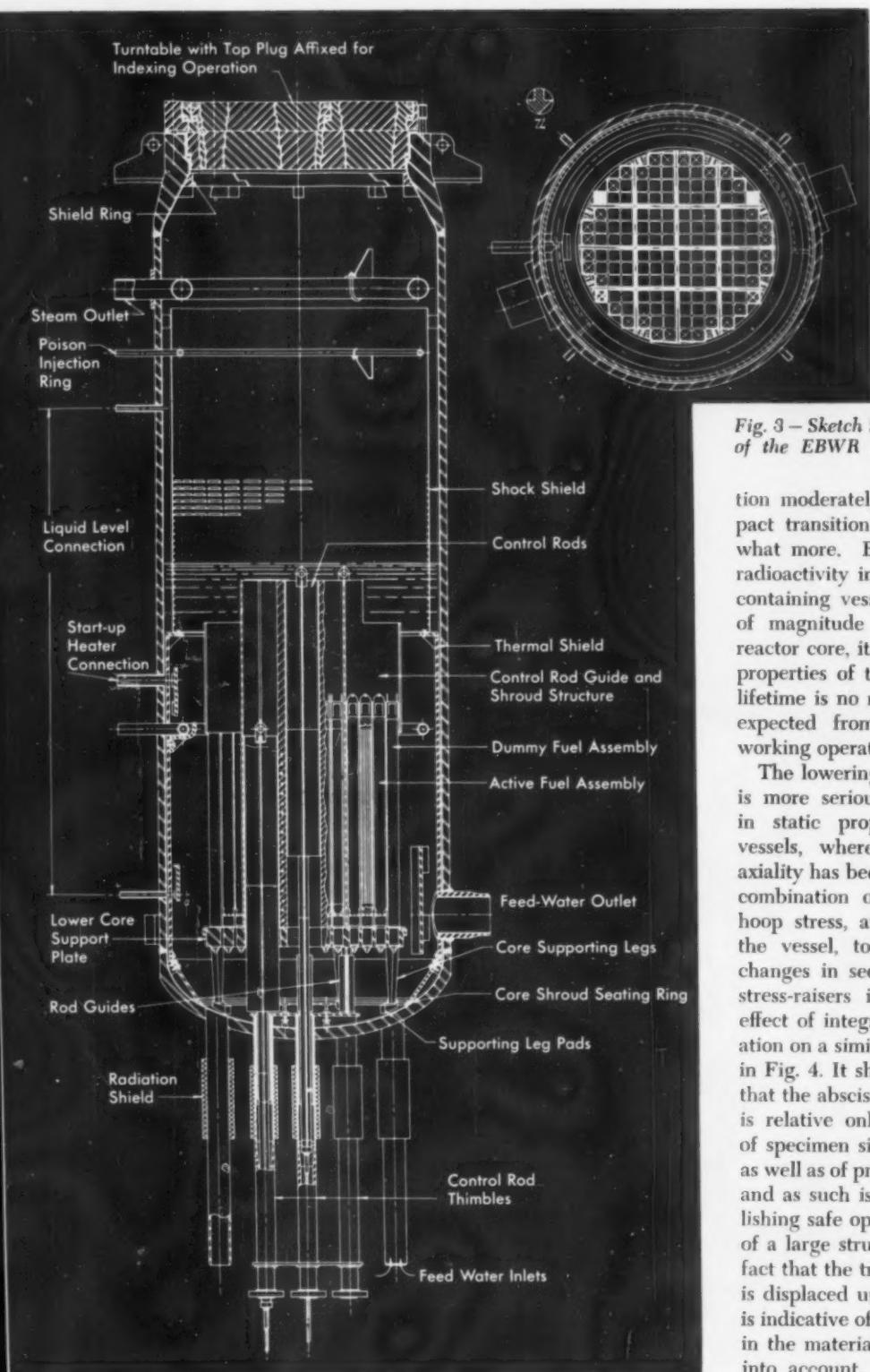


Fig. 3 — Sketch Showing Details of the EBWR Pressure Vessel

tion moderately, and raise its impact transition temperature somewhat more. Because the level of radioactivity in the vicinity of the containing vessel is several orders of magnitude below that in the reactor core, its effect on the static properties of the steel after a full lifetime is no more than would be expected from a moderate cold working operation.

The lowering of impact strength is more serious than any change in static properties in pressure vessels, where a degree of triaxiality has been introduced by the combination of internal pressure, hoop stress, and axial stresses on the vessel, together with abrupt changes in section and accidental stress-raiser in the welds. The effect of integrated neutron irradiation on a similar steel is illustrated in Fig. 4. It should be pointed out that the abscissa scale in this figure is relative only, being a function of specimen size and stress system as well as of properties of the metal, and as such is not useful in establishing safe operating temperatures of a large structure. However, the fact that the transition temperature is displaced upward by irradiation is indicative of an embrittling effect in the material and must be taken into account.

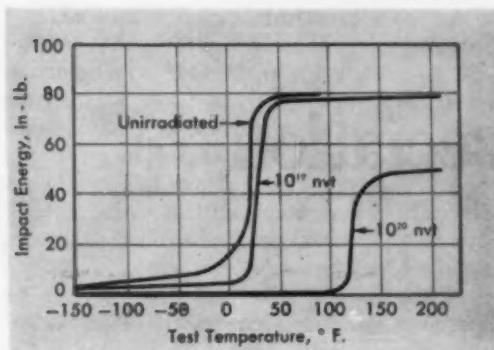


Fig. 4—Effect of Irradiation on the Impact Properties of a Normalized A.S.T.M. A-212 Grade B Steel. Nvt is unit of neutron irradiation

For these reasons, the design must attempt to (a) reduce the radiation level at the vessel by interposition of barriers, if possible, and (b) eliminate abrupt changes of section, insofar as possible. Control is needed against stress-raisers, such as gross inclusions in the steel. Precautions in welding techniques were necessary to an even greater extent than in conventional boilers for steam power plants.

The presence of gamma radiation, apart from neutron bombardment, contributes materially to heating of intermediate layers of the pressure vessel steel, because the region of maximum absorption of these rays lies somewhat below the incident surface. The resulting temperature gradient in the wall of the pressure vessel gives rise to internal thermal stresses in the shell during operation, which was a complication not encountered in conventional boiler design.

High Absorptive Components

The thermal shield and the control rods were made of boron stainless steel, their function being to soak up excess neutrons and convert their energy to heat. The thermal shield protects the pressure vessel against too much radiation. The control rods, by progressive insertion into the reactor core, limit the chain reaction and regulate the power level of the reactor.

Boron incorporated in these structures is the absorptive agent, being about 1% (by weight) in the thermal shield and 2% in the control rods.

Because of high absorption, radiation damage by neutrons is again the villain in these materials. Boron has the evil nature of changing to lithium plus helium under irradiation. In ten years at full power, it has been calculated that the control rods of EBWR will evolve about 30 times their

own volume in helium gas, which has to go somewhere.

Supports and Other Structural Materials

In the cooling system, stainless steel is used on those parts which come in contact with steam or water, because of the tenacious protective oxide film which forms and provides a shield against further attack.

Common structural materials, unless they contain highly absorptive chemical elements such as boron, cadmium, or some of the rare earths, are not serious targets for irradiation damage, especially in the absence of impact, triaxial, or cyclic stresses. Problems arising with these metals are primarily those of design, rather than of material. This is not to minimize their importance, but only to classify them as being of secondary interest to metallurgists.

The Metallurgical Role

Metallurgists, of course, participate directly in the production of fuel elements. Another function of the metallurgist in the design and construction of reactors is to build up a fund of knowledge about promising new metals and alloys—their mechanical and thermal properties, their behavior under irradiation and under corrosion in unusual media. This fund of new data should not only be made available but also actively brought to the attention of the reactor engineers on its own merit.

Those who are charged with the design of reactors must consider the needs of physics, heat transfer, materials, economics and a welter of other available information. So their reluctance to specify a promising new superalloy is probably made on the basis of something far removed from the arts of metallurgy. Two reactors later it may be just what the doctor ordered. In addition, some better acquaintance with it in the interim will give increased confidence to the people who must share in the risk of its employment.

Meanwhile, the metallurgists try to anticipate requirements of a few years ahead in the assurance that a fair number of jackpots will more than pay their way.

Editor's Note: The complete technical story of Argonne Laboratory's EBWR is now available in book form as one of the Nuclear Technology Series, sponsored by the U.S. Atomic Energy Commission. The paper-bound volume, "Experimental Boiling Water Reactor," can be purchased from the Superintendent of Documents, U.S. Government Printing office, Washington 25, D.C., for \$2.25.

Biographical Appreciation . . .



J. Robert Townsend

**Director of Materials
and Standards Engineering
Sandia Corp.**

J. ROBERT TOWNSEND's career is another of those reassuring bits of proof that this is a land of opportunity. The son of a Baltimore church-muralist and choir director, young Bob's early ambition was to become a doctor. But when his father's health failed, he was forced to leave school and go to work.

Recognizing that medicine was not a very promising field for a man seeking to educate himself while working, Townsend fixed his hopes on engineering. His only preparation, aside from a natural curiosity about the nature of things, was the fundamental training in general science which had made up his premedical studies at Baltimore City College. So armed, Bob Townsend in 1920 began his long and distinguished career with the Bell Telephone System.

His first job was in the development laboratory where he was assigned the task of evaluating the Bower-Barff finish for steel desk telephones. Thus at the very outset he tackled a metallurgical problem, and it was on this early assignment that he began to formulate the principles upon which he has based his entire career. Townsend puts it this way: "In order to evaluate a material or a process, you must first bring it under quantitative control and measurement. If you can measure, you can evaluate change." This was 37 years ago. Today, as director of materials and standards engineering at Sandia Corp., in Albuquerque, N.M., Townsend is applying this same principle to the study of the effects of radiation on materials.

During his early years with the Bell System's old laboratories on West St., New York City, Townsend supplemented his experience with courses in mechanical engineering at Brooklyn Polytechnic Institute. Although he never received a college degree himself, Townsend is a strong supporter of formal education. Last year 17% of the scientists and engineers in his organization took graduate courses at the University of New Mexico. Technicians in his group find it easy to get assigned to night jobs if they wish to attend university classes during the day.

Townsend attributes the fact that he has been able to succeed in a highly technical field despite limited formal education to two things. First, he points out, the Bell Laboratories is one of the world's greatest educational institutions. Second, he adds, truly competent professional people are always willing to share their knowledge and insights with others.

But his colleagues are likely to point to other

reasons for his success. For example Robert Poole, vice-president of development at Sandia, and for 30 years an associate of Townsend's, has this to say: "Over and above a high level of competence, Bob Townsend has three characteristics which have made him a leader: dedication to a purpose, intolerance of mediocrity, and the ability to get top people to work together."

The objective to which he has been dedicated throughout his career is that of seeking out the unique properties in materials which particularly suit them for specific applications. In this field he was one of the pioneers in bringing order to the testing of nonferrous metals. This activity led to his being made chairman of the group which resolved the metals, coatings, insulation and processes to be used on the Havana-Key West telephone cable, and later broadly applied to the transatlantic telephone cable.

Because of his interest in quantitative measurement and process control, Townsend early acquired an interest in the development and application of standards. He organized and developed the first materials and environmental laboratory at the Bell Laboratories and did much to establish the concept of materials engineering as it is practiced today. Both through his work in the Bell System and as a consultant to the Office of Defense Mobilization, Townsend has worked to establish the broad principles of substitution and conservation of materials. These principles have led to the present-day concept that conservation is best achieved by utilizing the unique properties of every material in optimum applications.

Townsend made direct contributions to our national defense in both world wars. During World War I, he served as a civilian consultant at the Aberdeen Proving Grounds. Since the beginning of World War II, he has been consultant to or member of a long list of committees and study groups in the field of materials. A complete listing of these activities would be rather formidable, but a few will be noted. He was, for example, a member of the Technical Industrial Intelligence Committee of the Foreign Economic Administration which investigated German technology and processes in 1945. From 1949 to 1951 he was chairman of the Panel on Ordnance Materials of the Research and Development Board. At the present time he is consultant to the Assistant Secretary of Defense for Research and Development and to the Office of Defense Mobilization; a member of the Technical Advisory Panel on Materials and of the

Advisory Committee on Materials to the American Standards Association; and chairman of the Panel on Ordnance Materials. He is also chairman of the Materials Advisory Board of the National Academy of Sciences, a group of scientists engaged in materials problems under contract with the Department of Defense and the Armed Forces.

The two professional organizations in which Townsend has been most active are the American Standards Association and the American Society for Testing Materials. In the former, he has, during the past quarter century, worked on six standards committees and nine administrative committees and has participated in six standardization projects. Recently he was nominated by his associates for the office of vice-president and for award of the Standards Medal.

In the A.S.T.M. he has been no less active. He served as a member of the executive com-

mittee from 1938 to 1949, and was in turn vice-president and president. He was awarded the Dudley Medal in 1930 for his work on standards for nonferrous metals.

No attempt will be made even to summarize the long bibliography of articles and papers which Mr. Townsend has contributed over the years. Suffice it to say that it began in 1927 with a study of telephone cable sheath alloys and ranges widely across the field of metals, standards, and testing. One of his most recent endeavors was a study of the national nickel situation prepared for the Office of Defense Mobilization. He recommended that the base of production be broadened and that nickel be thus made available for present and new uses rather than creating scarcity by enforced stockpiling.

In 1952, Townsend assumed his present post with the Sandia Corp., a Western Electric subsidiary engaged in ordnance work for the



An Introduction to Physical and Process Metallurgy

Reviewed by J. GORDON PARR*

TEXTBOOK OF METALLURGY, by A. R. Bailey, MacMillan & Co., Ltd., Rev. Ed., London, 1956. 560 p. 30s. net.

IN WHAT we are led to believe were the good old days of 50 or 60 years ago, a man might compile a textbook of metallurgy and, in the compass of a few hundred pages, write pretty well all that his readers expected on the subject. Or, even if he failed to do this, his readers were usually broad-minded enough to forgive him his omissions. But today, in an age when thousands of pages of script are written about such trivialities as right-handed screw dislocations in body-

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centered tetragonal structures, each of us is usually aware of the depth of one or two very narrow topics, and we are therefore much less tolerant of general textbooks with a wider subject range. When we *do* read a general text, we are ready to leap upon the author for leaving out material that pertains to our own forte, but we are rarely ready to admit that most of the book contains material with which we are not very conversant.

Mr. Bailey's book is already a familiar introduction to metallurgy. It describes itself as a "modern and thorough introduction to physical and process metallurgy for students of metallurgy at universities and technical colleges". As an introduction to metallurgy it is excellent in its content and clear in its presentation. While I hope that the students to whom Mr. Bailey directs his book read it, I think that it is also the sort of text from which almost any of us might benefit. It is, for example, a book that a steelmaker should keep on his shelf so that when

Atomic Energy Commission. As director of materials and standards engineering for this 6800-man atom-age laboratory, Townsend has had a unique opportunity to combine his interests in a comprehensive program.

The very structure of the organization he has assembled at Sandia reflects his philosophy of materials engineering. One of his three departments is devoted entirely to materials engineering. The second is responsible for developing and maintaining primary standards for the entire A.E.C. complex. The third is engaged in large-scale testing of materials and components and is equipped with centrifuges, shake tables, drop tables, drop towers, and even a 3000-ft. sled track. Thus Townsend has achieved the millennium — he can analyze, measure, and test to his heart's content!

Enough has been said to give some notion of J. R. Townsend as a metallurgist and a man of

science. But Bob Townsend has always found time to lead a full life away from the laboratory.

The comfortable home in which he lives with his wife and 21-year-old son Peter Grey Townsend is full of signs of this other side of his life. The walls are decorated with Townsend originals. (Mrs. Townsend explains that these are a result of the depression in the 30's. The Bell Laboratories at this time went on a four-day week, and her husband took advantage of the enforced leisure to attend art school and has continued to paint as a hobby ever since.)

Other hobbies include camping, golfing, riding, sailing, gardening, hunting, leathercraft, and carpentry, at most of which he is unusually proficient. His approach to such activities is exactly the same as that to his professional activities — "You figure out what you want to do and how to do it — then get at it!"

W. F. CARSTENS

a nephew phones to ask how the electron microscope works, or what, precisely, is meant by "peritectic", or how lead is de-silvered, the questioner has more than the bluff of his profession to work with.

I suppose a reviewer might demonstrate his cleverness by pointing out what appear to be a few small errors of fact, but these are so slight that to mention them would throw into a wrong perspective all that is good about the book. He might, too, express his disappointment that in a modern book, even at an introductory level, subjects such as high-temperature alloys and titanium metallurgy are not included. But such omissions are, I think, inherent to the pattern of Mr. Bailey's text. After an introduction to physical metallurgy (175 pages), the extraction metallurgy sections deal first with general principles and procedures (97 pages) and then with specific processes (82 pages). The book concludes with chapters on fabrication (92 pages) testing and pyrometry (50 pages), appendices of data and equilibrium diagrams, and questions. In such a framework there is no easy way of dealing with the mechanical properties, treatment and uses, of specific metals and alloys, except when examples are needed to illustrate a particular point in the text.

Mr. Bailey's difficulty is, perhaps, illustrated by the fact that a few pages on the physical metallurgy of iron and steel are inserted rather

uncomfortably into the chapter on iron and steel-making. But clearly, if Mr. Bailey had woven threads of the engineering metallurgy of many alloys into his already tight fabric — in fact, if he had inserted everything that he perhaps felt inclined to — the book would have been a most unwieldy one. It might also have become something more than an introduction. Therefore, while another author of another 560-page textbook of introductory metallurgy might have used a completely different approach with, probably, quite a lot of different material, this does not detract from the value of Mr. Bailey's book.

Since the book was written and published in England, prospective readers might anticipate the use of odd British specification numbers, and, possibly, descriptions of old English practices. They would be mistaken; the book is free from code specifications and appears to be up to date on processes that are used throughout the world. The only non-American convention is the use of the Celsius temperature scale, and to my way of thinking, this is one of the more sensible quirks of the British. It should be pointed out, too (but this shows the other side of the coin) that although the book is "Revised and Reprinted, 1956," it contains very few and very minor changes from the original 1954 edition. If you have the 1954 copy, don't get another; but if you have no copy at all and like to dig wide instead of deep, the book is a good buy.

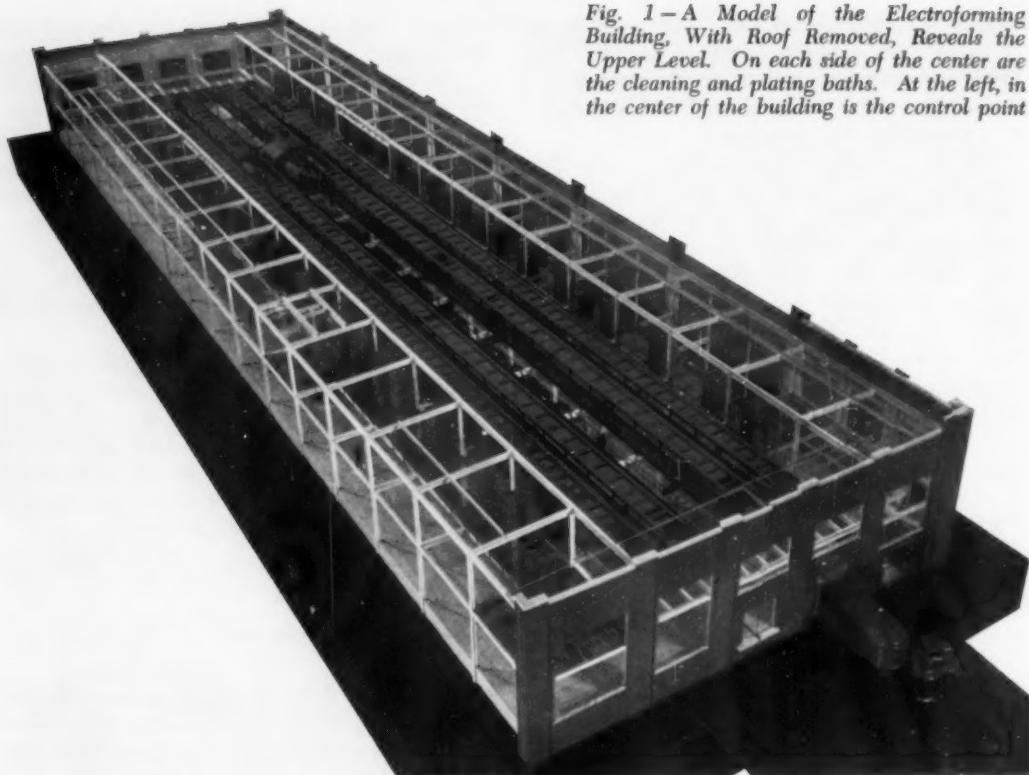


Fig. 1 - A Model of the Electroforming Building, With Roof Removed, Reveals the Upper Level. On each side of the center are the cleaning and plating baths. At the left, in the center of the building is the control point

Electroforming of Telephone Drop Wire Conductor

By ROBERT J. BACHMAN*

TELEPHONE DROP WIRE, the familiar aerial service connection between the telephone pole and the customer's home, consists of a pair of copper-clad steel conductors positioned in a cotton-wrapped rubber extrusion covered by a black neoprene weatherproof jacket. Nearly two billion conductor feet of this wire is required by the Bell Telephone System annually. In order to meet these needs, the Western Electric Co., the System's manufacturing and supply unit, has designed and built an electroforming plant at its Point Breeze Works in Baltimore, Md.† There two huge electroforming machines operate 24 hr. a day to make the copper-clad steel conductors. The plant layout and processes are

*Engineer, Western Electric Co., Inc., Point Breeze Works, Baltimore, Md.

†EDITOR'S NOTE: Generally the term electroforming is applied to a somewhat different process in which a metal shape is built up on a disposable matrix through electrodeposition. In the Western Electric process the functional properties of a wire are substantially changed, and the term is used to distinguish from purely decorative electroplating.

Conductance is precisely measured and thickness of metal deposition is controlled as steel wire is coated with copper, lead, and brass at the rate of 100 ft. per min. (LI7, TIb, 17-7; ST, Cu)

unique in many ways. Fifty continuous wire strands are simultaneously coated. Automatic instruments and controls measure and control conductance during the plating operation.

The operation begins with a steel wire which must be coated with adherent copper. The copper serves the dual purpose of lowering the electrical resistance of the conductor and providing corrosion resistance for the underlying steel. Steel provides the conductor with the strength required for drop wire service, but high strength must be tempered with a moderate amount of elongation or ductility. Meeting these specifications, the wire will give adequate support to distributed loads such as ice and wind and also resist shock loads imparted by falling tree limbs and other debris during storms.

The core material is a single strand of improved plow steel of the type used in making wire rope. It is a hard drawn wire with approximately 0.65 to 0.75% carbon and meets tests of

250,000 to 290,000 psi. breaking strength. The steel core wire measures 0.033 in. in diameter within commercial tolerances.

Because the surface of the wire as received from the steel manufacturer is covered with some oil, dirt and wire drawing compounds, the first operation in the process must remove these contaminants. Cleaning is done by passing the wire through a heated, specially formulated alkali solution in which the wire is anodic. A vigorous evolution of gas, caused by passage of electric current in the presence of the alkaline solution, removes these unwanted compounds effectively.

The next step removes traces of rust or scale on the wire in a sulphuric acid pickling bath operated at room temperature. A light etch given to the wire in this solution assists materially in promoting a firm bonding surface on the steel for the subsequent copper application.

A critical operation in the process is the first deposition of copper over the steel core which follows the cleaning steps. At this point, an immediate introduction of the steel into the more efficient acid-type copper plating bath is not feasible because a nonadherent galvanic replacement coating of copper would cover the bare steel. To prevent this occurrence, the Western

Fig. 2 — Steel Core Wire, Fanning Out From the Reels. In the distance a worker is butt welding the end of one reel to the beginning of another



Electric process calls for the steel to be given its initial coating of copper in a combination of two different copper cyanide baths, which produce a total deposit slightly more than 0.0001 in. thick. A fine grain structure in the copper coating, a result of precise adjustments of the deposition current densities and chemical compositions, tends to produce a fine crystalline structure in subsequent applications of copper over this preliminary coating.

Clad with a thin, fine-grained coat of copper, the wire enters an acid type plating bath where the copper can be deposited at a rate several times as fast as occurs in the alkaline copper cyanide bath. The acid solution is a combination of fluoboric acid and copper fluoborate. Though copper fluoborate is highly corrosive, its use is more than justified by the high current densities obtainable — 2000 amp. per sq.ft. of wire surface being entirely feasible.

When wire leaves the copper fluoborate solution, the copper thickness has been increased to approximately 0.0025 in. Although the 0.0025-in. thickness of copper is perfectly uniform around the steel, it still possesses the columnar grain structure characteristic of electrodeposits. In order to obtain a fine random grain structure, the wire runs through an annealer which is heated

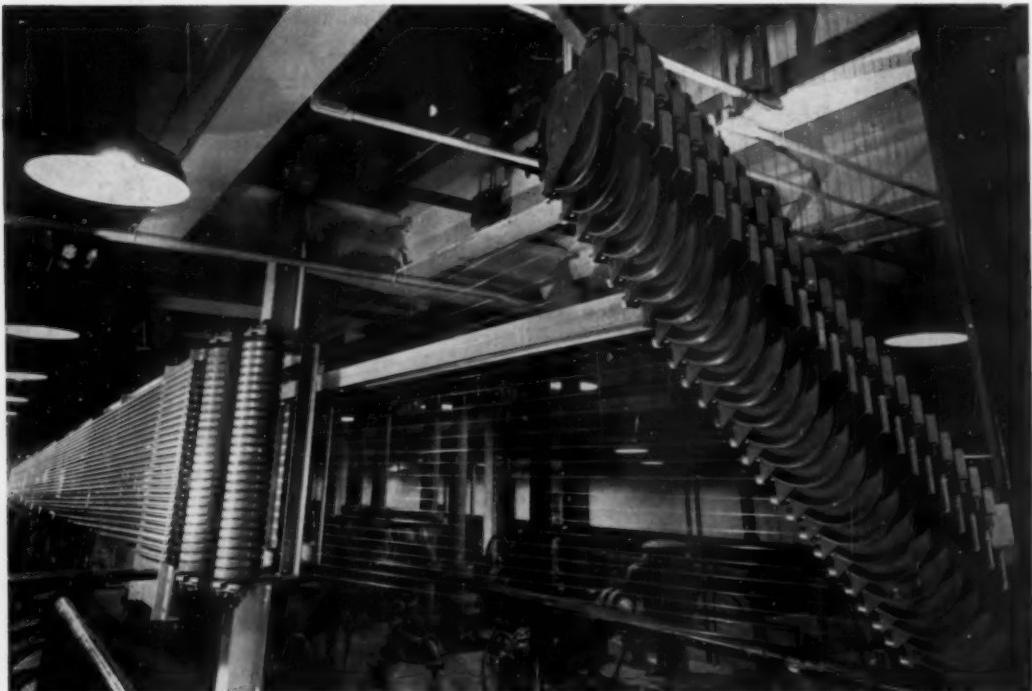
by a flow of alternating current in the wire. As the wire leaves the annealer, it is quenched in a bath of cold water. Three important changes occur during the annealing operation:

1. The copper becomes fully annealed, giving it a fine random grain structure that provides additional corrosion protection to the steel.
2. The electrical conductivity of the deposited copper is increased.
3. By virtue of subcritical heating, the steel is strain relieved. This increases the elongation properties of the steel without appreciably sacrificing its breaking strength.

Although the annealer has a steam atmosphere so as to reduce the tendency of copper on the wire to oxidize, some unavoidable oxide formation must be removed by a passage through a bath of fluosilicic acid, the next step of the process.

After copper plating is completed, the conductor receives a thin coating of lead (from a lead fluosilicate solution) which in turn is covered by a thin layer of brass, both electrolytically deposited. A chemical reaction between the sulphur in the rubber and the copper in the

Fig. 3 — From the Supply Reels at the Left, the Wires Are Guided at the Right to the Upper Level for Subsequent Plating



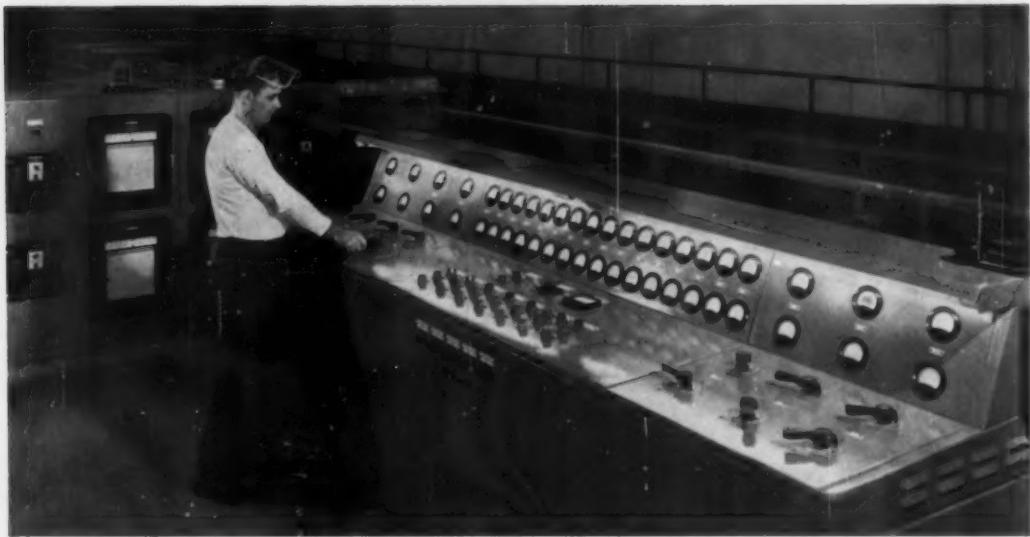


Fig. 4—Central Control Point. All meters, controls and recording instruments are together for easy reference

brass provides a high degree of adhesion between the conductor and the rubber extruded around the wire in the subsequent insulating process. Insulation is applied in a separate building. The thin continuous barrier of lead interposed between the brass and the thick coat of copper effectively prevents the chemical action

initiated by the sulphur from penetrating below the brass into the copper. Lead and brass deposits are each only a few millionths of an inch thick. Brass is applied in a copper-zinc cyanide bath in which temperature, current density, pH, and chemical concentrations are controlled to very close tolerances.

Fig. 5—A View From One End of the Building at the Upper Level. The row of cells directly in view forms one half of the total cells for each machine

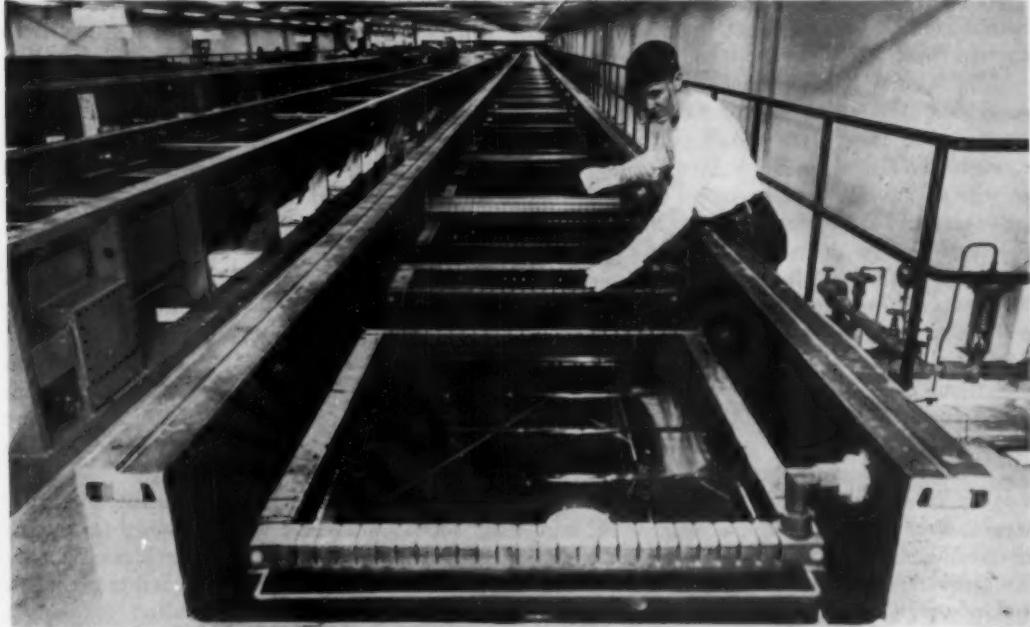
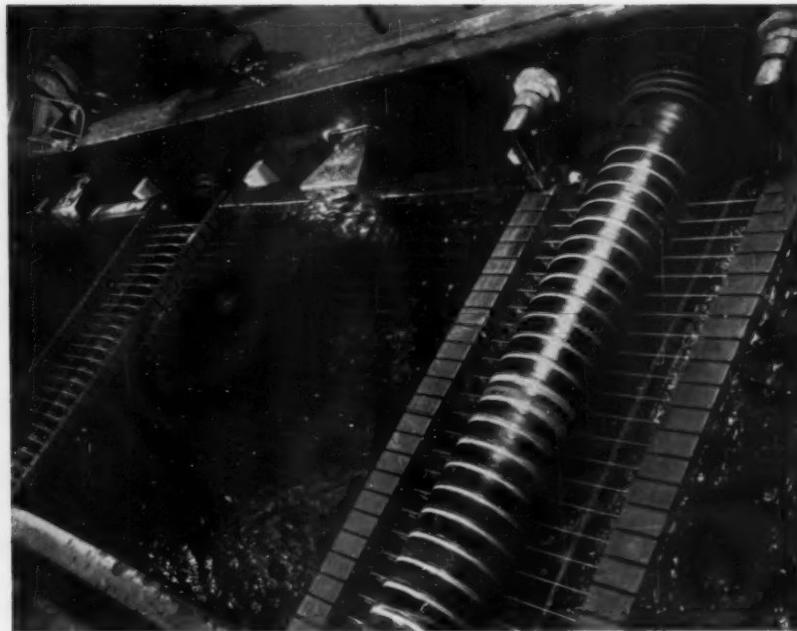


Fig. 6 – A Typical Cleaning or Plating Cell, With Narrow Sections on Each Side of the Cell Receiving the Overflow of Liquid From the Slotted Weirs



The plating machine is divided between two building levels. Cleaning and electroplating operations are performed exclusively on the upper level in the order described above. Operations in the lower level of the building include steel wire payoff and windup; material handling; solution mixing, storage, filtration, pumping, and heating.

Steel wire is supplied to the machine from the manufacturer's reels. Provision for an automatic transfer from the last wrap on any emptying reel to a new full reel makes the wire feed continuous. Wire is fed "over-end" from stationary reels lying flat on one end. Provision is made for the accessibility of the inner ends of wire coils so they can be joined at will to the outer ends of subsequent reels, thereby obviating the need to stop operations to produce a continuous wire feed. A butt weld which joins the last wrap on the emptying reel to the first wrap on the standby full reel is not as strong as the wire itself and is removed at the wind-up operation. With this arrangement, plant operation is carried on a seven-day basis with no scheduled shutdowns.

Twenty-five wires are simultaneously processed side by side in one machine. Wires are kept separated at fixed distances, are propelled and electrically energized by passage over and under 104 grooved metal rollers. Uniform tensions and a closely regulated speed of 100 ft. per min. are

obtained from an electronically controlled drive system.

Direct current power, essential to the electrolytic operations, is provided by copper oxide water-cooled rectifiers. The direct current output from the rectifiers is automatically regulated to the proper value through equipment which measures the electrical resistance of the copper-steel conductor as it leaves the last plating bath. An exceptionally uniform product results from this close control.

The cleaning, depositing and annealing sections of the machine total approximately 600 ft. in length and each of the 25 channels contains a wire span of about 850 ft. from payoff to windup. On the upper or processing level each machine consists of sets of tanks arranged in the form of a rectangular "C", the long axis of which is about 300 ft. Wires to be plated rise from the lower to the upper level at the opening of the C, travel through the sets of plating tanks, and descend to the lower level again at the opening of the C. Pay-off and windup stations are in line on the lower level beneath the machine for about three-quarters of its length. The building itself is 340 ft. long.

Carefully planned for substantially automatic production, the plant is fully manned for round-the-clock operation of both machines by only six men per shift with the assistance of a material handler on one 8-hr. shift.

Present Utilization of Titanium

STAFF REPORT

Still too costly for common use, titanium and its alloys are finding many military and civilian applications where high material costs can be justified by the advantages obtained. Greater uniformity of properties, variety of alloys available, lower cost and added user experience point to a steady increase in titanium's future acceptance. (T24, T29, T2, 17-7; Ti)

TITANIUM has been described in the recent past as the metal with a promising future. How is that promise actually working out? We learned the answer to this question at the Titanium Conference held concurrently with the Western Metal Congress in Los Angeles in March 1957.

In general, titanium is living up to its promise; in fact it can be said that some of the implied pledges are redeemed. There are three fields where titanium is in use now — military aircraft, army ordnance equipment and the process industries. To be sure there have been some ill-fated starts; experience again serves as the best teacher.

Titanium's acceptance isn't new as a story of the use of metals. During the last century, aluminum has grown from an interesting laboratory curiosity to an indispensable metal. Magnesium has followed this same course in the lifetime of many of us. Now comes titanium to help satisfy new metal demands.

Each of these metals had something different to offer, although aluminum, magnesium, and now titanium all offer low weight per volume. The first automobiles had no aluminum; today's use a significant quantity. Magnesium, when first tried by the car-makers in the 1920's, stumbled, and not because of price alone. Will titanium ever be used in automobiles? Probably not until it has more generally matured in aircraft use.

Several recent meetings under  auspices have highlighted the hot strength requirements of metals for fast aircraft now being built and for the ever-increasing speeds to be achieved by aircraft in the future. But superior strength-

weight ratios at temperatures above those possible with aluminum and magnesium are titanium's contribution to high-speed aircraft. Its corrosion resistance alone brings it into the chemical and process industries.

A recent report from an investment advisory service pointed out the properties of titanium noted above and indicated by its very appearance the widespread general interest in this mis-named "Wonder Metal". Early in World War II magnesium production was counted in pounds, thousands or millions to be sure. Even now titanium production after less than 10 years from its commercial introduction is quoted in this report in thousands of tons.

Production Increases

Consider also the actual 1956 production of 15,000 tons of titanium sponge for 5000 tons of mill products, and 1957 output of 28,000 tons to make 15,000 tons of mill products. Titanium in a single decade has equaled, proportionately, the growth of other metals which took 50 years.

In giving the present status of titanium (at the Titanium Conference) the problems yet to be solved were reported as well as the forms in which it might be used.

Well, where is it going and why is not more of it used?

Titanium's major use is for skin of high-speed aircraft, for support members and for engine parts, especially those that operate above room temperature at medium loads and must likewise be corrosion resistant. It is used for chemical apparatus in severely corrosive environments. In these uses titanium is varied in its

composition from the pure metal (for chemical plants) to alloys of 90 to 95%. This alloy picture is, of course, a changing one. The table below lists some of the currently used alloys.

TYPE	SPECIFICATION	COMPOSITION
Ti-150 A	PWA 678	3% Cr, 1.5% Fe
Ti-140 A	AMS 4923	2 Cr, 2 Fe, 2 Mo
6Al-4V	PWA 682	6 Al, 4 V
C 130-AM	AMS 4925	4 Al, 4 Mn
A 110-AT	PWA 684	5 Al, 2.5 Sn

Aside from these familiar alloys the older 8% Mn alloy has tensile properties of the order of 110,000 psi. and the newer 6% Al, 4% V upwards of 170,000 psi. at room temperatures. Increasing molybdenum considerably in a high-aluminum alloy (Ti, 7% Al, 3% Mo) gives an alloy with highest creep resistance and rupture strength at 1000° F., and a "Schapiro Index" (yield strength divided by unit weight) of 525,000 at 1000° F.

Now we are getting somewhere! It's comparable to the stainless steels when both are heat treated.

Titanium's use in an engine mount fitting (generally cubic in shape, 6 in. maximum dimension with $\frac{1}{4}$ -in. walls) was illustrated. However there are enormous material losses along the way from the first metallic sponge to ingots and from billets to forgings and finally to heat treated finished parts. These compound the price paid for an already costly metal.

Yet titanium bulkhead assemblies are made of stretch-formed and joggled angles and curved flanges. Tail cones of interceptor airplanes are made with titanium skins. Weldments of ti-

tanium are used in spot weld designs for engine shrouds. Fusion welding can be done in inert gas atmospheres to produce seam welds.

Predictions of the rate of increasing use of titanium haven't always been met. Five years ago it was predicted that 35,000 tons would be required in airframes (considering the present weight of airframes being produced). With benefit of hindsight we now find only about 1500 tons actually used. But the prophets still expect the ratio ultimately will be achieved.

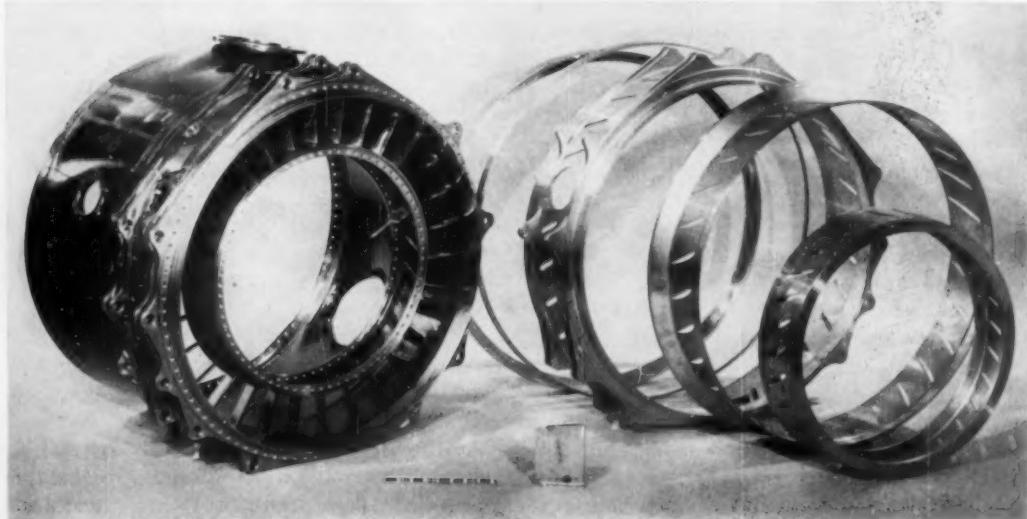
High Strengths Demanded

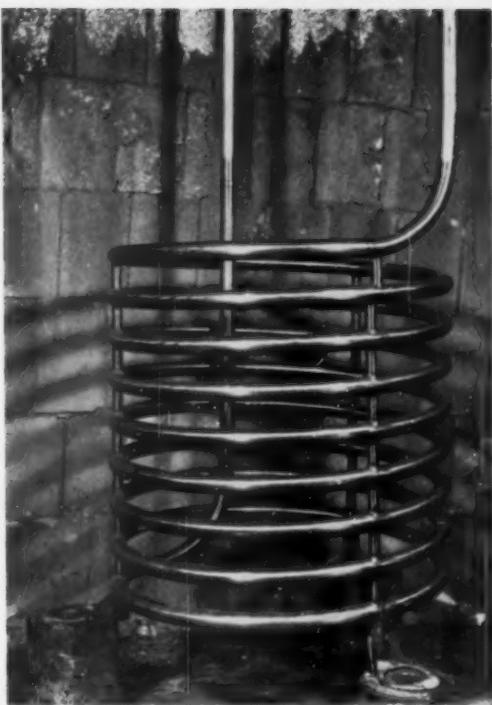
To do this the users want 180,000-psi. titanium alloys and want to get it all the time. They want 140,000 psi. at 650° F. One aircraft manufacturer would set a goal of 200,000 psi. at room temperature for forgings.

Aircraft engineers want thinner sheets that are wider, longer and to closer tolerances, and they showed just how airframes could be built for even better performance from such material. They also showed why, to achieve aircraft weight savings, they can pay for it in otherwise expensive metals. An extensive research program resulted in satisfactory titanium bolts to replace those of other high-temperature materials in aircraft applications.

The step from aircraft to missiles seems short and logical, but one is astounded by the require-

Among the Military Aircraft Applications of Titanium Alloys Are the Axial Flow Compressors of the J-57 Jet Engine (Shown Here), Engine Fittings, Bulkheads and Shrouds





Titanium Is Used In Heat Exchangers Handling Corrosive Liquids. High corrosion resistance permits use of thin-walled tubing, thus providing higher heat transfer rates

ments for materials of construction. It reminds one of the position engine designers were in at the time of World War II. Engines would last only minutes if operated at full load, full speed. Such a condition was approached in a power dive. The only reason the plane still had engines was that it could only climb so high and hence the dive took such a short time that these extreme conditions soon ran out — the planes ran out of space, so the engines didn't operate at such outputs long enough to ruin them!

Now we make missiles and they heat themselves aerodynamically but their life is measured in seconds (see William M. Canterbury, *Metal Progress* for May 1957, p. 99) so we can still have them to carry their loads and deliver their goods. But again it is a matter of rather short range.

Titanium is in real use in jet engines. While axial flow compressors were first designed in steel, titanium for blading was a "natural". Here the lower density, higher corrosion resistance and improved ratios of creep strength and fatigue strength to density were used to advantage.

Interchangeable Materials

Compressors of one engine manufacturer are of the same configuration in titanium as in steel to permit interchangeability. The manufacturing improvement has not only been in reliability with improved processing but in increased "utilization ratio" (finished weight to input weight). Compressor cases are made now of titanium, both pure metal and alloy. Inlet cases are being welded of extrusions and sheets. forgings of substantial size are welded together to improve utilization ratios. Undoubtedly the biggest single use of titanium is in the J-57 engine, admirable from all points of view except cost which is so high that these engines are used almost exclusively in the long-range B-52 bomber, where a pound saved is worth almost anything.

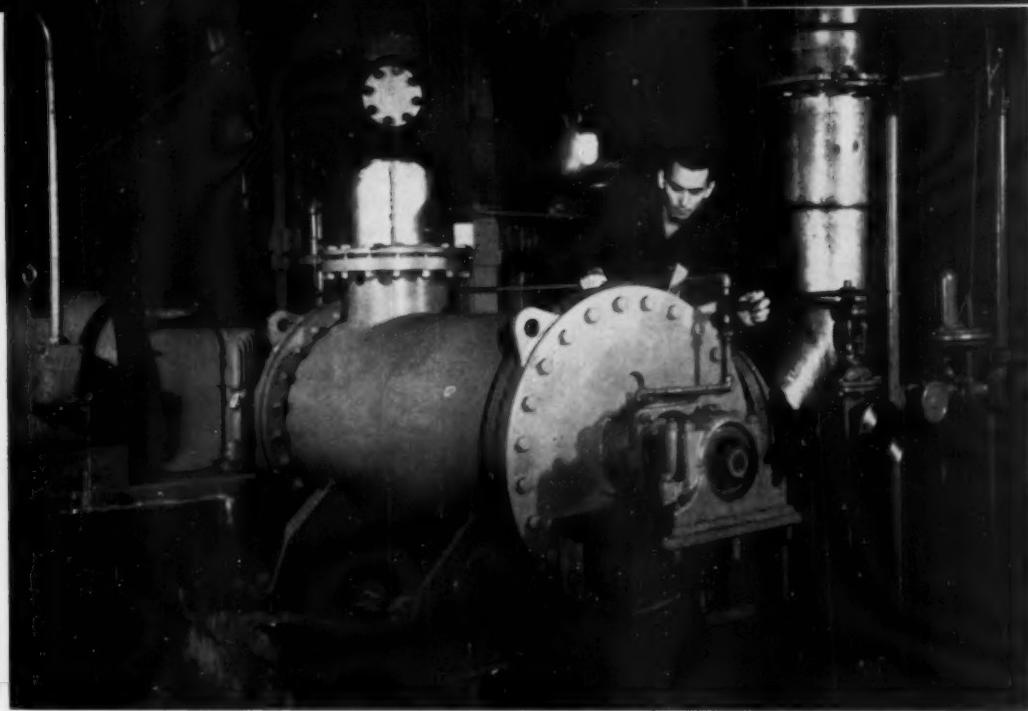
As indicated, titanium is important in today's missiles. Missiles are in reality unmanned airplanes operating in the speed range of many Mach numbers. When you consider the thermal limitations of materials in terms of the steady-state skin temperatures due to aerodynamic heating at any given altitude, say 30,000 ft., aluminum is good to about Mach 2 (400° F.); titanium to Mach 3.5 (1000° F.) and the nickel alloy Inconel "X" to Mach 4.5 (1500° F.).

By "Chem-Mill" process, weight in lower stress areas has been reduced in a typical rib section built up by welding. Titanium is also being actually used in missile parts that are brazed together — as, for example, in heat exchanger tubes and in bearing housings.

Brazed joints are used in electrical and electro-mechanical systems. Joints are between titanium and corrosion resistant steels, both austenitic and heat treatable ferritic types. Brazing is done inside glass or plastic containers with induction heating, so time at elevated temperature is so short that embrittlement due to diffusion of the brazing alloy into the titanium is minimized. In missiles, as in airframes and engines, large cases and load-bearing covers are being made of titanium. In missiles, electrical requirements often demand metals of high conductivity, so plating with precious metals permits its use in spite of the low electrical conductivity of titanium and its alloys.

Military Armor

The Air Force is not the only group that is weight conscious. The Army is using titanium because of its strength-weight ratio, since now-a-days mobility is so important.



Titanium Is Being Used Increasingly to Line Tanks and Vessels. Chlorine dioxide is added to paper pulp for bleaching in this titanium-lined mixer

For instance, they are using titanium to replace steel armor. Weight saving amounts to 25% for the same ballistic protection. Again, by using titanium in the running gear, as much as 5% of the total weight of a tank is saved.

Man-carried equipment can be lightened, as for example in flame thrower fuel and gas tanks. When titanium is used for a mortar base plate one man can carry it where two men formerly were required.

Process Industry Uses

We heard early that titanium was used in the chemical and process industries and there it has made remarkable strides. Here the important property is corrosion resistance rather than strength-weight characteristics. For example, highly corrosive slurry is handled in the Cuban plant where nickel and cobalt are being separated from a complex iron ore.

A titanium jet after-condenser, in service for more than 33 months continuously, replaces a stainless steel unit that failed in six. Brackish water shows no measurable effect on the titanium even though the solution also contains dilute nitric and organic acids. Titanium is outlasting stainless four to one in handling a nitric acid solution with free nitrogen oxide at 400° F. and 350 psi. Here welded coils as well as agitators, thermowells and valve trim are used. Low thermal expansion coefficient of titanium enables the unit to operate without increased expansion stresses.

In a steam jet diffuser at high pressures and with dilute hydrochloric acid, titanium is outlasting other materials 18 to 1. In such examples of remarkable corrosion resistance it is easily recognized that the material's high initial cost can be justified. Longer life reduces both the cost of replacement and permits continuous operation without down-time. In some instances the use of titanium has permitted higher process temperatures or process solution strengths with resulting efficiency increases and without corrosion hazard.

In process industry applications commercially pure titanium has been most generally used. It has adequate strength, works and welds easily, and has the required corrosion resistance. Sheets, plates, wire, bars and forgings are all being used.

Welded food processing kettles were illustrated at the conference. A mixer with titanium lining for bleaching paper pulp and a heat exchanger were other specific examples shown. Titanium shells are also being used as tank and pressure vessel liners in the process industries. Rem-Cru Titanium reports its orders for civilian uses for 1957 to be six times those in 1956 — one result of very active promotion.

So here now is the answer to a "Critical Points" question put in May 1955: "At any rate, do you have any use for this Wonder Metal?" An emphatic "Yes".



Relieves traffic congestion. To handle the ten million cars a year which now funnel onto the 3-lane Carquinez Bridge, (right) the State of California is building this second bridge connect-

ing the San Francisco Bay area and the Sacramento Valley. Use of nickel-containing USS "T-1" Steel in critical truss members has simplified design...reduced unnecessary weight...saved money.

A tale of two bridges ...and an \$800,000 saving

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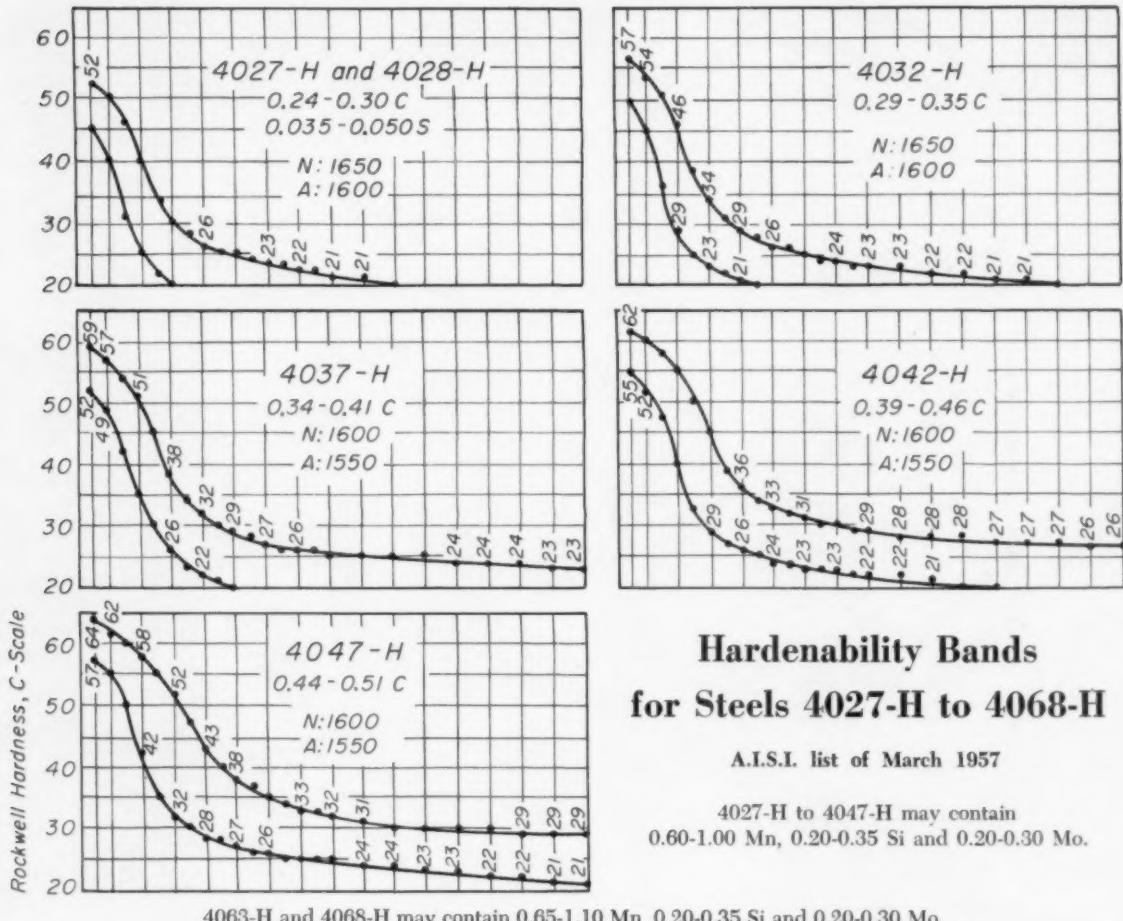
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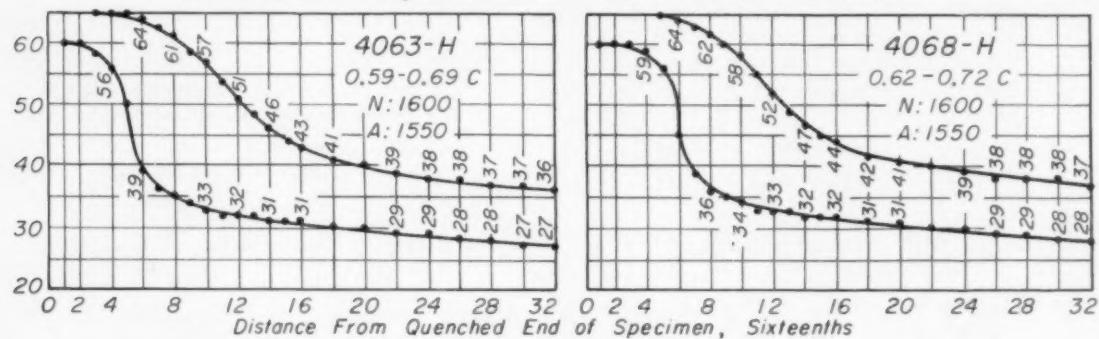
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Hardenability Bands for Steels 4027-H to 4068-H

A.I.S.I. list of March 1957

4027-H to 4047-H may contain
0.60-1.00 Mn, 0.20-0.35 Si and 0.20-0.30 Mo.



N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.). Hardness limits

are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

Diameters of Rounds With Same as Quenched Hardness							Location in Round	Quench
3.8							Surface	
1.1	2.0	2.9	3.8	4.8	5.8	6.7	3/4 Radius From Center	Mild Water Quench
0.7	1.2	1.6	2.0	2.4	2.8	3.2	Center	
0.8	1.8	2.5	3.0	3.4	3.8		Surface	
0.5	1.0	1.6	2.0	2.4	2.8	3.2	3/4 Radius From Center	Mild Oil Quench
0.2	0.6	1.0	1.4	1.7	2.0	2.4	Center	

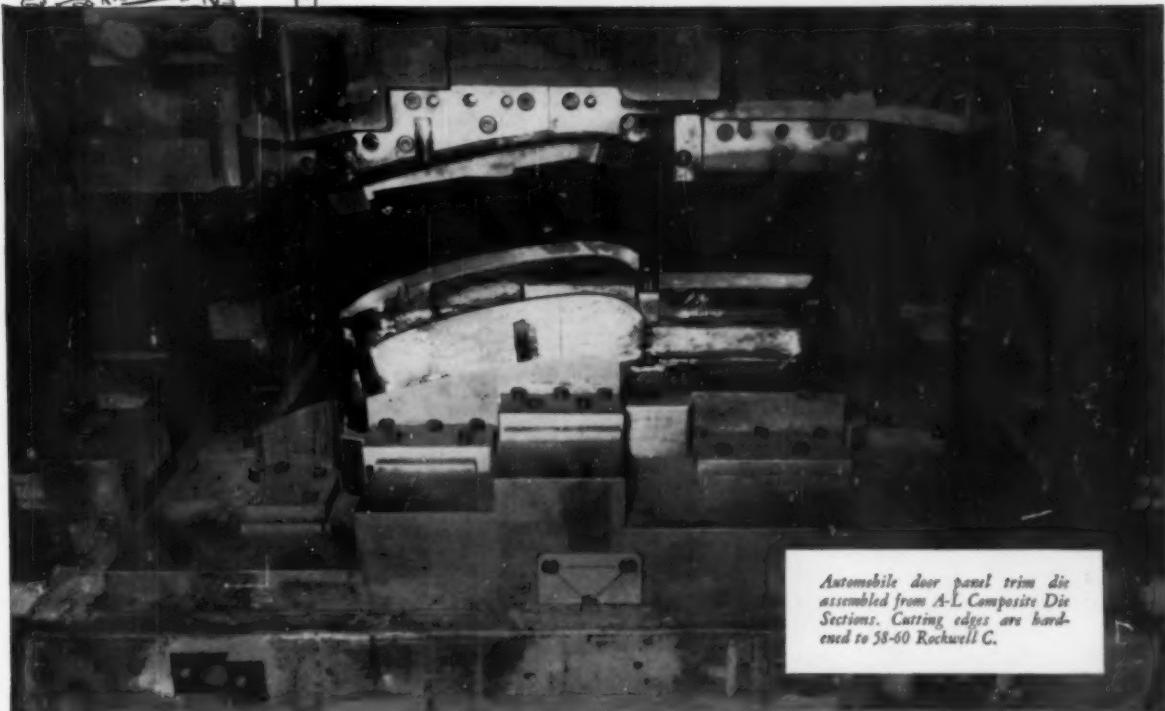
0 2 4 6 8 10 12 14 16 18 Distance From Quenched End



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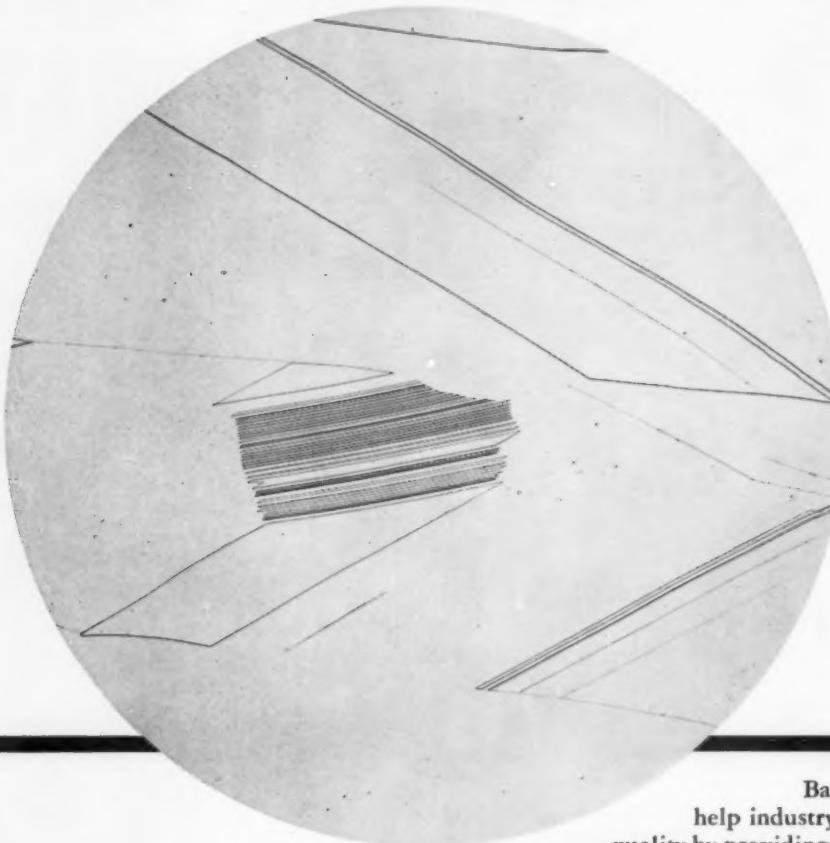
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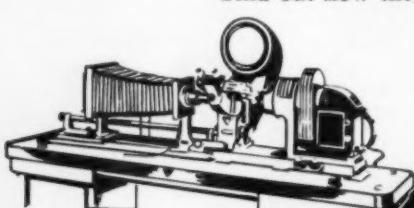
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Equipment and Procedures for Rapid Heating and Testing

STAFF REPORT

Advanced electronic equipment is needed to measure and record accurately the temperature and deformation in tests completed in seconds.

Rapid heating is done by electrical resistance or in hot fluid.
Results vary widely unless test conditions and metallic state
are rigidly controlled. (Q general, 1-3, 2-12)

ONE OF THE MOST pressing and persistent needs of metals engineers today is a metal — or group of metals — capable of withstanding the complex conditions imposed by the flight of supersonic missiles. Not only are the materials subjected to constant stresses at extremely high temperatures, but the rise from low temperature to the extreme high takes place in a matter of seconds.

To find metals that will meet the rigid conditions of missile flight it has been necessary to develop a completely new set of testing techniques capable of determining high-temperature strengths. This new field of testing materials is only now reaching a state where the available knowledge of the variables involved is resulting in the development of testing equipment to provide accurate, reproducible data.

Several types of equipment were described in papers presented at the Western Metal Congress, Los Angeles, in March 1957. Salient features of the testing facilities of four different organizations were described and will be summarized here.

As Alan V. Levy, Marquardt Aircraft Co., pointed out in his paper "Performance of Materials at Elevated Temperatures", the loading of structural members in missiles and missile power plants may require that the test temperature be reached in a matter of seconds and the test completed to fracture in considerably less than a minute. Test temperatures are usually in ranges where the metallurgical structure of the alloy is unstable and the creep rates quite high. Under these conditions, the following factors must be carefully taken into account in determining the material's strength:

Short-Time Tensile Properties of 2024-T3 Aluminum at 600° F.

TESTING VARIABLES		PROPERTIES AT 600° F.		
SOAK TIME	TESTING TIME	ULTIMATE STRENGTH	YIELD STRENGTH	ELONGATION IN 2 IN.
90 min.	2 to 5 min.	14,000 psi.	11,000 psi.	—
30 min.	2 to 5 min.	19,000	15,000	—
2 sec.	3 sec.	27,500	—	—
10 min.	30 sec.	28,000*	—	—
100 sec.	0.08 sec.	34,000	31,700	7%
30 min.	0.08 sec.	26,500	22,000	11
100 sec.	25 min.	17,300	17,100	7
30 min.	25 min.	13,500	13,000	10
	1 to 2 min.	20,000	—	—

*Extrapolated.

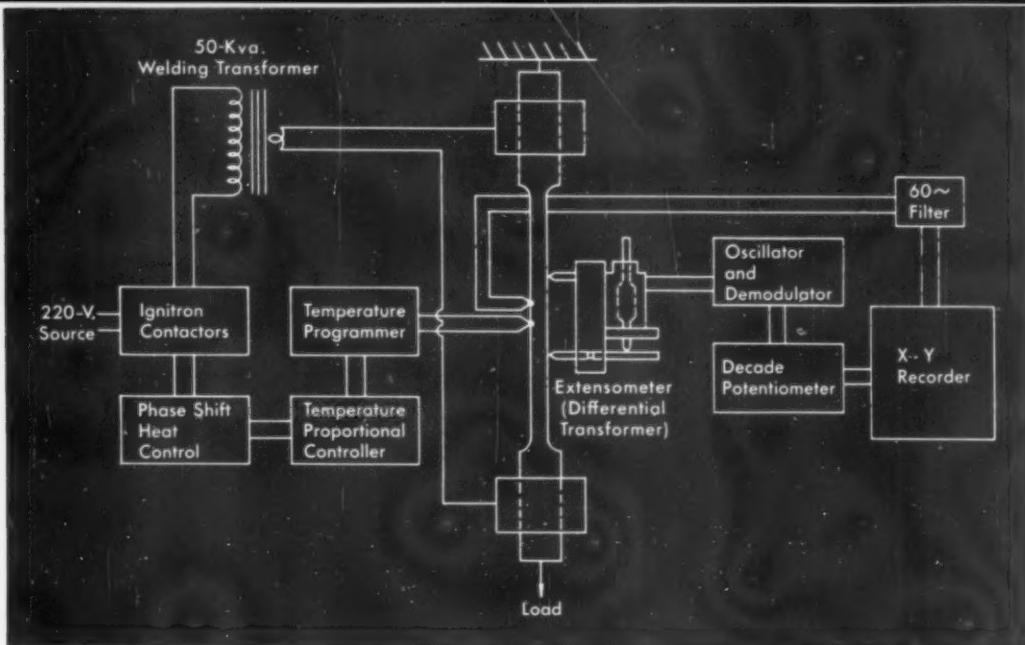


Fig. 1 - A 50-Kva. Welding Transformer Is the Heat Source in the Navy's China Lake High-Heating-Rate Testing Machine

1. Loss of strength at the elevated temperature.
2. Creep rate of the material during the test.
3. Effect of strain rate on the resultant strength level.
4. Effect of aging or other metallurgical changes during the test.

A typical example of the effect of these variables is shown in Table I. Tensile and yield strengths of 2024-T3 aluminum alloy at 600° F. as shown in the literature are assembled in this table. It can be seen that, depending upon the test conditions, tensile strengths from 13,500 to 34,000 psi. were obtained. Evidently all of the special factors cited above affected the results.

Arc Welder Heat Source

The equipment used to determine the data presented in the paper "Strength of Metals Undergoing Rapid Heating", by W. K. Smith and A. T. Robinson, U. S. Naval Ordnance Test Station, China Lake, Calif., was developed specifically for this purpose.

Two high-heating-rate testing machines are in use there. Both are capable of heating at the rate of 100° F. per sec. One machine uses a 600-amp. direct current arc welder as the source of heating current. A rheostat on the welder is set to deliver a constant current. When electrical resistance of the metal increases with temperature, the I^2R also increases. However, as the temperature of the specimen increases, heat losses due to convection and radiation also increase. Thus, the resultant heating rate is relatively constant.

A second and newer high-heating-rate testing

machine uses a 50-kva. welding transformer as a source (Fig. 1). It is equipped with proportioning controls that follow the differential signal from a thermocouple and program controller, and can provide any desired temperature-time program. Use of alternating current as a heating source has certain advantages: (a) Voltage superimposed on the thermocouple electromotive force is damped out in the recording instrument, and (b) during fracture there is less damage to the specimen by arcing — thus the fracture can be studied more accurately.

In tests intended to simulate rocket service, load is applied to the specimen before heating starts. It is convenient to use a lever system when required loads are high.

Temperature of a specimen during a test is measured by iron-constantan or Chromel-Alumel thermocouples made from 30-gage wires. When alternating current is used, a second thermocouple is attached near the first. One is used for control, and the other for recording on the Y-axis of an X-Y recorder. Wires are individually spot welded near the middle of the gage length.

Strain is measured by a specially built clip-on extensometer. The stainless steel knife edges are insulated from each other to prevent short-circulating the heating current. One knife edge pivots and actuates the iron core in the differential transformer. Primary input to the differential transformer is supplied by an oscillator at 3000 cycles per sec. Output from the sec-

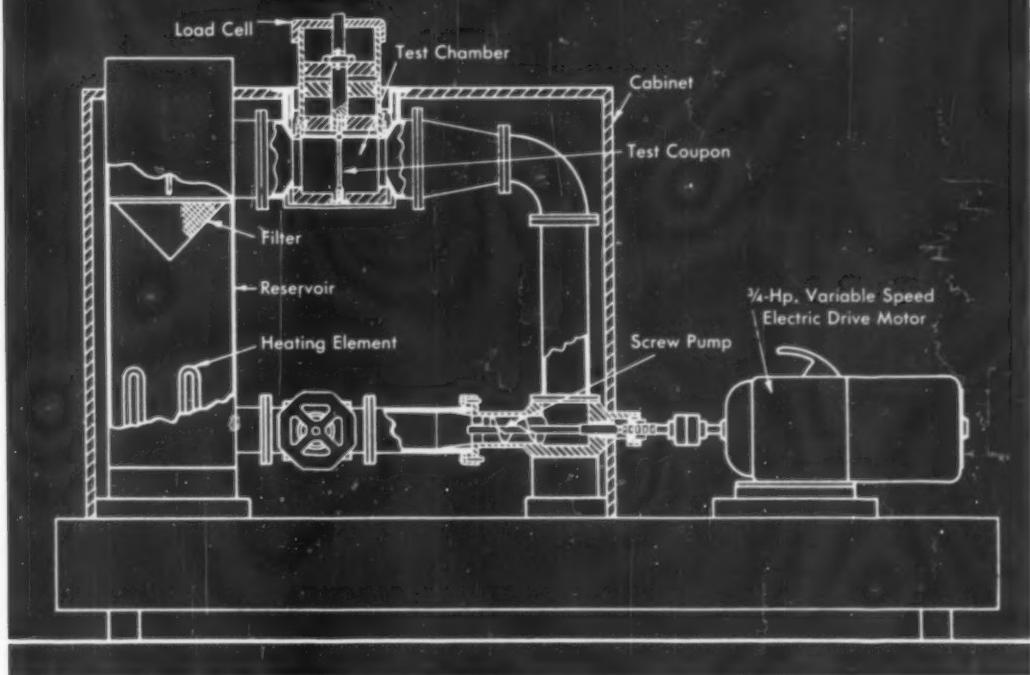


Fig. 2 - Oil Bath High-Temperature Test Unit

ondary coils is filtered to remove 60-cycle pickup from the heating circuit, rectified, and fed to the X-axis of the X-Y recorder.

Test specimens can be prepared either from bar stock or sheet. For flat specimens, a reduced section, 0.200×0.063 in. and about 5 in. long, has been found acceptable. The specimen should be free of notches or undercuts which might cause hot spots due to local increases in electrical resistance. Heat is unavoidably taken from specimens by the grips, so it is best to provide at least 1 in. between the extensometer knife edges and shoulders of the specimen.

Under these circumstances, temperature along the gage length will be uniform to within $\pm 10^{\circ}$ F. at a heating rate of 100° F. per sec.

Fluid Heat Source

A close approximation of the conditions encountered in flight at moderate Mach numbers is achieved through the use of a hot, incompressible fluid in equipment used at Convair-Pomona Division of General Dynamics Corp. The unit is capable of heating test specimens at rates up to 60° F. per sec. and reaches maximums approaching 650° F. when using a low flash point oil. As reported in the paper "The Fluid Analogy to Aerodynamic Heating" by T. C. McGill, senior metallurgist, heating rates are controlled by the velocity of fluid passed through the test section. Velocities can be varied from 2 to 20 ft. per sec. by speed control of the prime mover.

McGill indicates that fluids other than oil can be used to attain temperatures in higher ranges. Among these are molten nitrite-nitrate salts to simulate sea level flight at Mach 3.0, and liquid metals such as lead and lead-bismuth or molten chlorides for temperatures between 1000 and 2000° F.

The Convair-Pomona test equipment (Fig. 2) consists of three main elements: (a) a hydraulically operated test fixture, (b) a heat transfer section for the fluid (which is heated to the desired temperature) where at the indicated time the hydraulic test fixture is inserted to heat the test specimen, and (c) the control section for all operations. All the various test units at Convair-Pomona are different in appearance although basically they operate on the same general principles.

Resistance Welder Heat Source

Test equipment used by Southern Research Institute in Birmingham, Ala., is capable of heating specimens as high as 2250° F., the maximum depending upon the material. Heating to test temperature requires 10 sec. This equipment is described in the paper entitled "Effect of Variations in Holding Time and Strain Rate on the Tensile Properties of Structural Metals at Elevated Temperatures", presented by J. R. Kattus. A typical machine is shown in Fig. 3.

Specimens are resistance heated through power supplied by a 10-kva. transformer.

Rough control of power for both heating and holding is afforded by ten transformer taps. Switches are provided, one for selecting the heating power and another for selecting holding power. As specimens approach the control temperature, relays automatically engage the holding tap.

Accurate and reproducible temperature measurements are obtained by flash welding 36-gage Chromel and Alumel wires to the specimens at intervals of 0.2 in. At 1200° F. temperature indications from the welded-on thermocouples averaged 14° F. lower than those of a reference couple. The temperature differential decreased linearly to zero at 400° F. In each test a control thermocouple is welded to the center of the gage length of the specimen and actuates a recorder controller.

Temperature uniformity in specimens is achieved by removing heat from the thinner center of the gage length by a slight stream of air.

In making short-time creep tests at Battelle Memorial Institute, a standard Battelle creep frame is used to load specimens. Stress is applied by dead weights on the end of a 9-to-1 ratio lever-arm system. Heating current is supplied by a 50-kva. resistance welding transformer operating from a 440-volt primary source. The transformer has eight steps of primary regulation together with both series and parallel secondary regulation. Constant temperature is provided through ignitrons which furnish additional power when needed.

The equipment provides heating rates, adjustable as desired, up to 600° F. per sec. Through the use of a second set of igniton contactors for rapid transformer tap changes, controlled heating rates as high as 1350° F. per sec. can be obtained. The equipment has no maximum operating temperature except as restricted by maximum operating temperature of thermocouples or the melting point of the test materials.

Specimens used in tests carried out on the Battelle equipment were 17 × 2 in. in over-all dimensions with a gage section 8 in. long and $\frac{1}{2}$ in. wide. The long gage length increases sensitivity and accuracy of creep measurements. Thickness of specimens ranges from about 0.025 to 0.065 in. depending upon the material.

Measurements of strain in the test specimens are made by a simple direct-current slide-wire extensometer unit. Extensometer rods are clamped outside the gage section at the relatively cool ends. This arrangement provides minimum thermal conduction to the extensometer. To

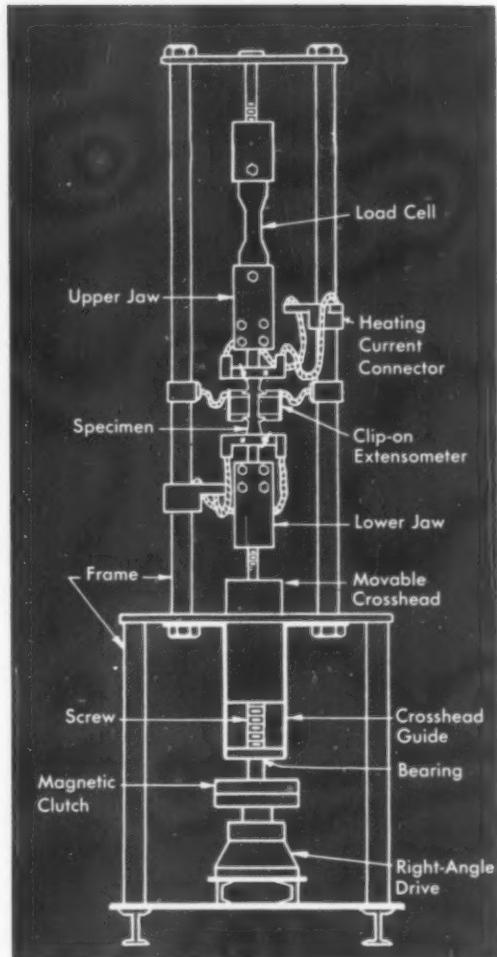
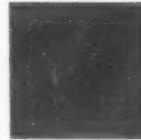


Fig. 3—In This Test Equipment at Southern Research Institute a 50-Kva. Resistance Welding Transformer Provides Heat as High as 2250° F.

minimize errors resulting from radiation of the hot specimen to the extension rods, the rods are made of Invar and surrounded by radiation shields of bright aluminum foil through which cooling air is blown.

A Final Precaution

One strong point made by the panel chairman was that unless all conditions of a test are made known, the data developed are of little value to another investigator. Currently there is almost no uniformity in methods or equipment for making short-time high-temperature tests, but one of the methods described by this group might well become the standard.



Recent Statistics on Metallurgical Education

By MICHAEL B. BEVER*

While numbers of B.S. degrees in metallurgy do not now reach the postwar peak from G. I. training, the current number (545 in 1955-56) is a higher proportion of all engineering degrees.

It is predicted that the figure will reach 750 in the near future and possibly 1000 within a few more years.

M.S. degrees have been about 160 in each of the last three years.

Ph.D. degrees show a steady increase from 42 in 1948-49 to 76 in 1955-56 (A3)

IN AN ARTICLE entitled "The Supply of Metallurgists with Graduate Training" in *Metal Progress* for August 1955 the author reported and analyzed statistics on graduate education in metallurgy in the United States for the six academic years from 1948-49 through 1953-54. That article was based on a survey which had been conducted by an informal study group. Subsequently, the American Society for Metals Foundation for Education and Research (F.E.R.) adopted this group as its "Committee on Educational Statistics". Under this sponsorship, the Committee enlarged the scope of its interests and, in particular, included undergraduate education in metallurgy. Also the annual surveys have been placed on a continuing basis.

The members of the informal study group

and of the first F.E.R. Committee on Educational Statistics were Alfred Bornemann (Stevens Institute of Technology), Morris Cohen (Massachusetts Institute of Technology), John P. Nielsen (New York University), W. O. Philbrook (Carnegie Institute of Technology), with the author (Massachusetts Institute of Technology) as chairman. This article presents the results of several recent surveys conducted by the Committee, and includes the last one which was completed in 1957 and concerns the 1955-56 academic year.

*Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. Contributions of ideas by members of the Committee on Educational Statistics are acknowledged gratefully, but the author alone is responsible for the statements made. The computations required for the analysis of the data were carried out by Marion G. Bever.

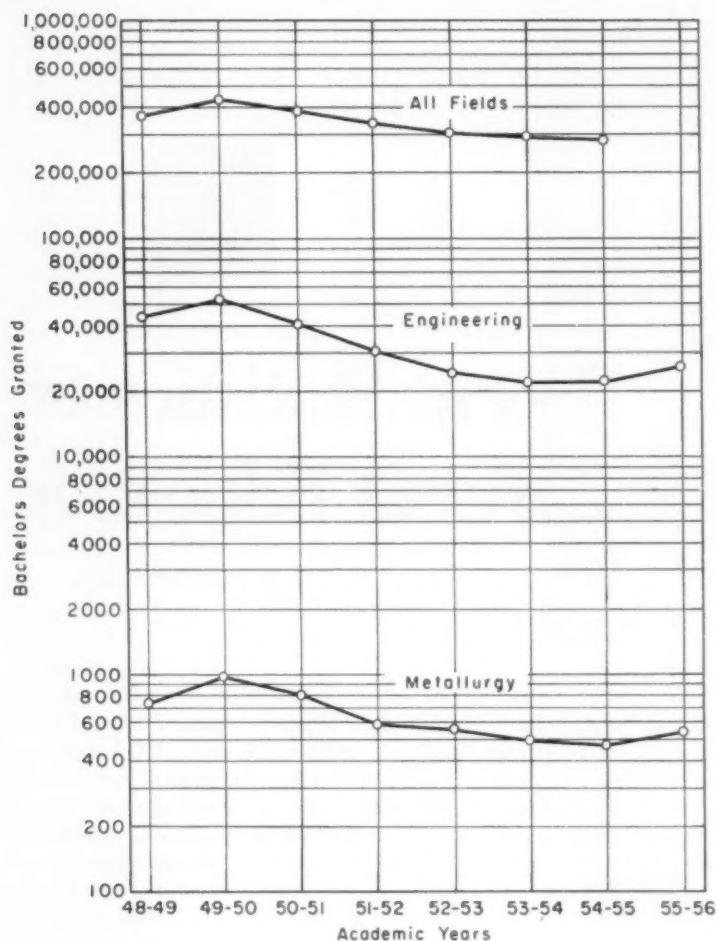


Fig. 1 — Number of Bachelors' Degrees Granted in All U.S. Institutions Year by Year Since 1948-1949*

Method of Surveys — The surveys were conducted by annual questionnaires sent to over 60 institutions in the United States. Most of these grant degrees in metallurgy; a few have metallurgical options in other departments. In each year only three or four with small enrollment failed to answer and the numbers of degrees granted by them were taken from government publications. Information was obtained from the same source on degrees granted by two institutions which have only recently started programs in metallurgy and to which no questionnaires had been sent. Consequently the national totals of degrees granted may be assumed to be nearly complete. Although some other questions were not answered in all returns, the samples were always adequate.

The questionnaires on scholarship aid were sent to 56 institutions in this country believed

to offer undergraduate curricula in metallurgy and to six in Canada; 33 of the American and all Canadian departments answered. This response represented over 60% of all departments and nearly 80% of the total enrollment. This coverage was satisfactory since the survey of scholarship aid was undertaken only to provide a representative picture.

*SOURCES OF DATA: (a) All Fields — "Earned Degrees Conferred by Higher Educational Institutions 1948-49" (and subsequent years), Office of Education, Federal Security Agency. (1952 and after: U.S. Department of Health, Education and Welfare.)

(b) Engineering — "Engineering Enrollments and Degrees, 1949" (and subsequent years), Office of Education, Federal Security Agency. (1952 and after: U.S. Department of Health, Education and Welfare.)

(c) Metallurgy — Same as (b) through 1953-54; F.E.R. Committee questionnaire thereafter.

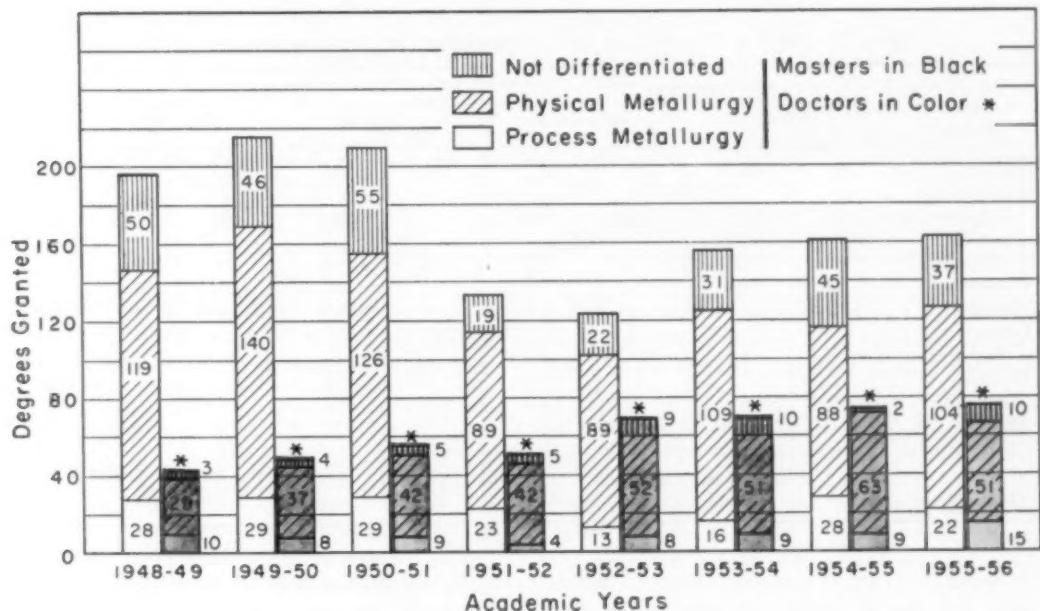


Fig. 2—Graduate Degrees in Metallurgy Granted in the U.S. During the Eight-Year Period 1948 to 1956. Black bars represent Masters' degrees; bars in color represent Doctors'

Definitions — The Committee spent serious effort on defining "metallurgy", its various subdivisions, and some other terms that were used in the questionnaires.

The latest wording of some of these definitions may be of interest.

Metallurgy for the purposes of this questionnaire comprises process metallurgy and physical metallurgy. It does not cover mining, ceramics or other related, but independent, fields.

A graduate degree in **Process Metallurgy** may be presumed to be granted to a person whose thesis was concerned with a problem in the field of process metallurgy (production or extractive metallurgy). This field is defined as the science and engineering of producing metals from raw

materials. Process metallurgy includes ore dressing (mineral engineering) if the work is done in a department of metallurgy or leads to a degree in metallurgy, and the candidate may be presumed to have had sufficient training in process metallurgy to be active in this field at a level commensurate with the level of the degree granted.

If a thesis on a problem in foundry or welding metallurgy primarily involves chemistry or subject matter closely related to process metallurgy (e.g., solidification), the degree should be reported under process metallurgy.

A graduate degree in **Physical Metallurgy** may be presumed to be granted to a person whose thesis was concerned with a problem in the field of physical metallurgy. This field is defined as the science underlying the relation between the treatment, structure and properties of metals and the engineering applications of this science, especially to fabrication and heat treatment. Physical metallurgy by this definition includes the "physics of metals" (if the thesis is done in a department of metallurgy) and "mechanical metallurgy" (such as plasticity of metals, metal shaping, metal joining, powder metallurgy).

If a thesis on a problem in foundry or weld-

Table I—Degrees in Metallurgy

YEAR	BACHELORS	MASTERS	DOCTORS
1948-49	..... (738)	197 (197)	42 (34)
1949-50	..... (961)	215 (184)	49 (46)
1950-51	..... (802)	210 (238)	56 (40)
1951-52	..... (581)	131 (136)	51 (53)
1952-53	..... (550)	124 (126)	69 (56)
1953-54	..... (495)	156 (139)	70 (53)
1954-55	474 (449)	161 (146)	74 (62)
1955-56	545 (485)	163 (139)	76 (72)

Figures in italics are from "Engineering Enrollments and Degrees, 1949" (and subsequent years), Office of Education, Federal Security Agency (1952 and after: U. S. Department of Health, Education and Welfare), Washington

Table II – Field of First Degree (B.S.) of Recipients of Graduate Degrees

BACHELORS' DEGREE	MASTERS				DOCTORS			
	1954-55		1948-1955		1954-55		1948-1955	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Metallurgy	99	63.9	701	68.7	52	70.2	261	68.3
Mechanical Engineering	26	16.8	82	8.0	7	9.5	30	7.9
Chemical Engineering	17	11.0	79	7.7	5	6.8	35	9.2
Chemistry	7	4.5	53	5.2	3	4.0	26	6.8
Physics	2	1.3	42	4.1	6	8.1	21	5.5
General Engineering	—	—	17	1.7	—	—	4	1.0
General Science	1	0.6	13	1.3	—	—	—	—
Mining Engineering	—	—	11	1.1	—	—	1	0.3
Others	3	1.9	22	2.2	1	1.4	4	1.0
Total known	155	100.0%	1020	100.0%	74	100.0%	382	100.0%

ing metallurgy primarily involves physical metallurgy, the degree should be reported in this classification.

The questionnaire suggested that graduate degrees be reported separately for "process metallurgy" and "physical metallurgy", regardless of whether or not this distinction appeared on diplomas or otherwise.

Degrees in Metallurgy

The numbers of degrees granted each year are probably the most representative single measure of current activity in metallurgical education.

Such enrollment figures are useful for projecting short-term trends, but they are less definite because they contain an unknown fraction of part-time students. By contrast, the degrees granted measure formal educational efforts carried to completion. However, they should not be interpreted as being equal to the number of persons available for employment, since numbers of new Bachelors and Masters continue their studies, and some students obtaining graduate degrees are already employed or on leave from their positions.

Bachelors' Degrees in metallurgy granted in the United States are shown in Table I. The figures in italics starting with the academic year 1948-49 are taken from the annual government bulletins noted. For the two years of our survey, our figures are larger than reported in the government bulletins.

Figure 1 shows the numbers of Bachelors' degrees granted in all branches of education in

the United States in engineering and in metallurgy each year since 1948-49. The logarithmic scale permits direct comparison of the rates of change on a percentage basis. The figures for all engineering and for metallurgy change at fairly similar rates, while the Bachelors' degrees granted in all fields are more stable.

It is likely that the number of Bachelors' degrees granted in metallurgy in 1956-57 increased somewhat over the preceding year. This increase and current enrollments suggest that the decline which began in 1950-51 has now run its course.

Graduate Degrees – Masters' and Doctors' degrees for the eight years starting in 1948-49 are also given in Table I. On the basis of the questionnaire they are shown in Fig. 2 in three categories – process metallurgy, physical metallurgy and "not differentiated".

The large annual totals of Masters' degrees in the post-war period were followed by a marked drop. In the last three years covered, the totals stabilized at a constant level. The Doctors' degrees continued their slight upward trend. If the graduate degrees are broken down into the categories of process metallurgy, physical metallurgy and "not differentiated", appreciable changes in these subdivisions appear from year to year.

Table I permits a comparison of the number of graduate degrees reported in this survey with the totals reported in Government publications. As for the Bachelors' degrees, the survey has again yielded many larger totals.

Only five Engineers' degrees in metallurgy

Table III — Foreign Students Receiving Degrees in Metallurgy

	1954-55			1955-56		
	BACHELORS	MASTERS	DOCTORS	BACHELORS	MASTERS	DOCTORS
Foreign students	6	18	5	13	19	10
Foreign students returning to home country	—	—	—	8	10	7

were granted by academic institutions in each of the academic years 1954-55 and 1955-56. This indicates the lack of numerical importance of this type of degree.

Other Aspects

Graduate Study in Metallurgy — The 1954-55 questionnaire included a query as to the field in which those receiving graduate degrees had obtained their Bachelors' degrees. Replies covering 155 out of 161 Masters' degrees and all 74 Doctors' degrees were returned. These data, together with seven-year totals for the period 1948-49 through 1954-55, are shown in Table II.

The large percentage of graduate students who took their undergraduate training in metallurgy may be noted. Mechanical and chemical engineering and to a lesser extent chemistry and physics also figure significantly, but the numbers of students entering metallurgy from these fields vary so much from year to year that only the seven-year totals should be considered.

Of the 74 Doctors' degrees granted in 1954-55, 56 or 75.7% went to persons holding Masters' degrees in metallurgy. The corresponding figures for the seven-year period 1948-55 are 274 or 71.7% with Masters' degrees in metallurgy.

Length of Study — The questionnaire for 1954-55 inquired about the length of study required for obtaining the various degrees. Only two institutions offered a full-time undergraduate curriculum in metallurgy as a five-year course. Six schools, located in urban or industrial centers, reported regular arrangements for part-time study toward the Bachelors' degree. The resulting increases in time required vary greatly.

Full-time Masters' candidates are reported to complete their studies in periods ranging from two terms to two academic years. Usually, this period, and especially its lower limit, increases by 50 to 100% if students hold research appointments within the institution and by several hundred percent if students are employed in industry.

The minimum time required for full-time study toward a doctorate is reported as two years, but most often it is three years. Research and other appointments and outside employment (where this is permitted) again increase the total time required; the reported increases differ widely among institutions.

Scholarship aid was the subject of a special survey which included Canadian institutions. The information dealt with scholarships received regardless of source, in 1955-56 by undergraduates majoring in metallurgy, and with scholarships specifically designated for students of metallurgy. Conditions are so complex and differ so much, institution to institution, that only a brief summary will be given here.

Out of a total enrollment of 2207 undergraduates covered by replies to the questionnaire, 400 or 18% received some form of scholarship aid. At most, 289 or 72% of these scholarships were specifically designated for students of metallurgy, while the balance came from general funds.

Half of the scholarships designated for students of metallurgy were supported by "foundations, technical societies, fraternal organizations". Industrial concerns supported directly about 40% of the scholarships; some, however, made contributions through foundations and such scholarships were not included in the figure of 40%. Only about 10% of the scholarships designated for undergraduates in metallurgy represented "endowment or other funds directly administered" by academic institutions, and funds granted by state or municipal bodies. Among the designated scholarships, about 12% provided \$50 to \$249 and about 41% \$250 to \$499 per year. About one-quarter carried stipends in the range of \$500 to \$749, while the remaining quarter received over \$750. There is reason to believe that frequently large grants, although reported as single scholarships, were actually distributed among several recipients.

Foreign Students — The numbers of foreign students receiving degrees in metallurgy are

Table IV – First Employment After Graduation in Two-year Period 1954-1956

FIRST EMPLOYMENT	BACHELORS		MASTERS		DOCTORS	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Industrial Operations	222	27.6	38	12.1	7	4.8
Research and development	144	17.9	104	33.2	82	56.6
Not differentiated	220	27.4	29	9.3	6	4.1
Academic						
Teaching	7	0.9	11	3.5	22	15.2
Research	18	2.2	10	3.2	8	5.5
Continued studies	89	11.1	70	22.4	1	0.7
Research institutes	13	1.6	10	3.2	9	6.2
Government	6	0.7	8	2.6	6	4.1
Military service	54	6.7	15	4.8	2	1.4
Other	31	3.9	18	5.7	2	1.4
Total	804	100.0%	313	100.0%	145	100.0%

given in Table III. The figures for 1955-56 also show the numbers of those returning to their home countries. The degrees accounted for in this manner are of the order of 2% of Bachelors' degrees and about 10% of graduate degrees. A deduction of 10%, therefore should be made in arriving at the number of persons with graduate training available for employment in the United States. The training of foreign students does not significantly interfere with the domestic supply since the capacity in many institutions exceeds enrollments, and some foreign students are added, at least temporarily, to the domestic supply of trained metallurgists.

Types of Employment

Table IV shows the types of employment or other activity entered into by recipients of degrees in metallurgy in the academic years 1954-55 and 1955-56. The samples tabulated amounted to 78.9, 96.6 and 96.7% for Bachelors, Masters and Doctors, respectively. This may be the first time that information on employment of metallurgists after graduation has become available.

Of the Bachelors 11.1% continued their studies; 22.4% of the Masters. Also, some of those entering employment with Bachelors' or Masters' degrees became part-time graduate students, but are not listed as such in Table IV. These groups are not the only source of advanced students in metallurgy. Each year a significant number of men leave industrial employment and undertake graduate studies. Nearly one-third of all graduate students entered metallurgy from other fields of undergraduate specialization.

Two-thirds of the Doctors are employed by industrial companies. The same applies to those Masters who do not continue their studies. An even larger fraction of those obtaining Bachelors' degrees enter industrial employment. Within the groups employed by industry, the fraction of those entering "operations" decreases as their degrees become more advanced. There is a corresponding increase in the fraction of those entering research and development.

Academic employment constitutes a significant proportion for persons with Doctors' degrees. Some of the individuals in this group may later leave academic employment. Only a smaller number can be expected to move in the reverse direction.

Employment by research institutes and the Government is nearly insignificant for new Bachelors. It becomes more important for those with higher degrees.

Conclusion and Forecast

The 1955 article arrived at a short-term forecast of 150 to 200 Masters' degrees and 60 to 80 Doctors' degrees per year. The figures for 1954-55 and 1955-56 fall within these ranges. At the present time, no revision in the forecast of Masters' degrees is indicated, while the expected range for Doctors' degrees should be raised slightly to 65 to 85 per year.

Major changes are most likely to occur in the undergraduate area, and it is safe at this time to predict increases. About 750 new Bachelors in metallurgy annually are probable in the immediate future and it seems entirely possible that in a few years this number will exceed 1000. ☺

Alloys for Precious Metal Jewelry

By RALPH H. ATKINSON*

Although an integral part of the broad field of metalworking, the precious metal jewelry manufacturing industry has developed its own unique materials and processes. Here the author describes the metals most frequently used by that industry. (Tgs, 17-7; Au, Ag, EG-c)

IN THE "CENSUS OF MANUFACTURERS" (1954) the precious metal jewelry category includes jewelry and other articles, to be worn or carried on the person, made of precious metal with or without precious stones, including cases and lighters, vanity cases and compacts, trimmings for umbrellas and canes, and jewel settings and mountings. "Precious metal", in addition to solid gold and the platinum metals, includes filled gold, rolled gold plate, filled palladium, rolled palladium plate, and sterling silver. Base metals electroplated with gold, rhodium or silver are included in "costume jewelry".

For purposes of the Census the precious metal jewelry industry has three main divisions:

1. Manufacturing of jeweler's findings.
2. Cutting and polishing of precious and semi-precious stones (lapidary).
3. Manufacture of articles of jewelry.

In the above classification jewelers' findings include stock-shop products such as sheet, wire and tubing for use in the manufacture of jewelry (46% of total in 1954), unassembled jewelry parts (36% of total) and machine chain (16% of total). However, those in the trade restrict the term "findings" to unassembled jewelry parts.

The relative size and importance of the industry as a whole, and its divisions, can be gaged from the statistics given in Table I. Of the total employed in the manufacture of jewelry, approximately 29,000 can be considered as engaged in a metal industry. Small establishments are the rule; only one in 40 has more than 100 employees

and only one company has more than 1000 employees. Eighty percent of the precious metal jewelry is made in four states: New York, New Jersey, Massachusetts and Rhode Island. Principal manufacturing centers are New York City, Providence, Attleboro and Newark.

Precious Metals for Jewelry

In Table II an attempt has been made to assemble data and estimates for the amount and value of the different metals used for jewelry in the year 1954. That year was chosen so metal data will be comparable with the census data given in Table I. The jewelry industry consumed 70,846 oz. of platinum metals of an estimated value of \$4,600,000 in 1954. The latter year, however, appears to have been an off year, because the average annual consumption of platinum metals for jewelry for the period 1941-52 was 114,000 oz. with an estimated value of \$7,700,000. In the absence of official data, it is necessary to make estimates of the annual consumption of the other metals, including gold, which continues by far to be the most important jewelry metal. It is estimated that in 1954 consumption of gold was 1,000,000 oz., approximately 45% of the total gold used by U. S. industry that year. The estimate is probably reasonable, because two rings for each of the

*Now retired, Mr. Atkinson was a metallurgist at International Nickel Research Laboratory. He resides in Westfield, N.J. This is the first of a series of four articles on jewelry manufacture.

1,500,000 brides married each year in the U.S. would require about 300,000 oz. of gold without taking other jewelry into account. Estimated consumption of silver at 500,000 oz. could be too low because silver jewelry is sold by chain stores as well as by retail jewelers. Manufacture of precious metal jewelry also requires significant amounts of base metals, chiefly as foundation metal of gold-filled and rolled gold plate. Base metals used include nickel, with an estimated annual consumption of 500,000 lb., copper (200,000 lb.) and zinc.

Values for the platinum metals rest on a broad basis of proved industrial uses. Jewelry accounts for only 25% of the consumption of these metals; in addition they have well-established uses in the chemical, electrical and dental fields. For instance, in the period 1941 to 1952, 45% of the palladium was taken for electrical uses, chiefly for the contacts of telephone relays. For platinum, an important new use has developed in the so-called "platforming" process for upgrading gasoline and it has also become a key metal in the manufacture of fiber glass.

Commercial Standards and Stamping Laws

Although there are no specifications in the ordinary sense for jewelry metals, it has long been customary to use a marking system to guarantee quality of silver and gold and thereby guard against fraud. London instituted a hall mark for silver and gold plate as long ago as 1300 A.D. In America the situation is complex because both Federal and State Governments are concerned with the quality of jewelry metals. In 1950, for instance, in addition to the National Stamping Act, 24 states had stamping laws for silver, 17 for karat gold and 5 for platinum. There are also commercial standards, promulgated by the National Bureau of Standards, for karat gold, gold-filled and rolled gold plate articles, silver in combination with gold, articles

Table I - 1954 Census Data for Precious Metal Jewelry Industry

	FINDINGS	LAPIDARY†	JEWELRY
Number of employees	5,371	1,759	23,455
Number of plants	234	333	1,327
Manufacturing cost*	31.4	10.6	145.6
Cost of materials*	38.0	23.0	112.6
Value of shipments*	69.4	33.6	258.1

*In millions of dollars.

†Lapidary shipments include jewelry diamonds (\$18.4 million) and industrial diamonds (\$5.1 million).

made wholly or in part of platinum, jewelry and novelties of silver. The principal composition requirements for silver, gold, platinum and palladium are summarized in Table III.

Two grades of silver are recognized for stamping purposes, namely, "sterling silver" (92.5%) and "coin silver" (90%). The stamping laws permit gold of any karat from 10 karat (41.65%) to 24 karat (100%) to be stamped, but in practice the popular jewelry grades are 14, 12, 10 and 18 karat in that order. "Karat gold" means not less than 10-karat gold, but a tolerance of one-half karat is allowed, or a tolerance of one karat if solder is used.

Stamping laws for platinum are complex due to a desire to make provision for stamping not only of platinum but also its alloys with the other metals of the platinum group. There has probably been some reluctance to write laws which might hinder development of a relatively new jewelry metal. As stamping laws stand at present, an article can be marked "platinum" if it contains at least 98.5% platinum group metals, of which platinum must be at least 93.5%. Provision is also made for the stamping of platinum alloys such as 90% platinum, 10% iridium; 80% platinum, 20% iridium; and 90% platinum, 10% rhodium, which have been developed to meet the need for hard jewelry platinum of high quality. The stamping laws and commercial standards

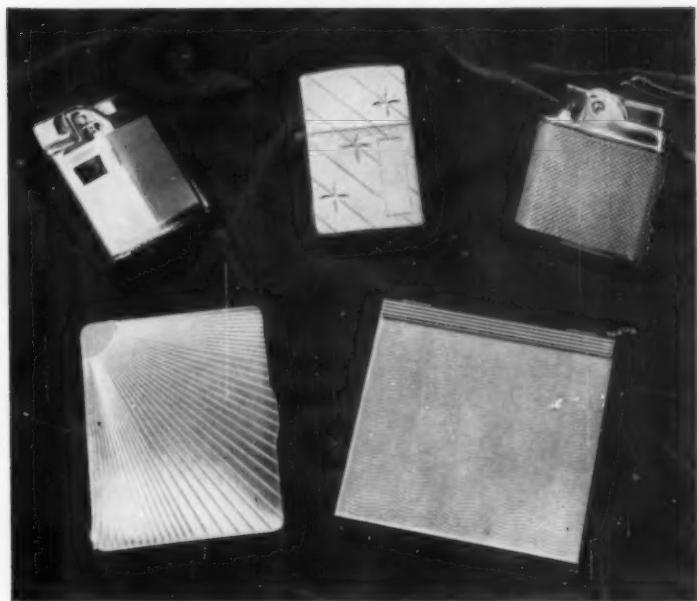
for platinum are probably not yet in final forms. Proposals are currently under consideration for raising the minimum platinum content and lowering the tolerance in these alloys.

As a jewelry metal, palladium is even newer than platinum and the stamping requirements dealing with it are less developed. How-

Table II - U.S. Consumption of Metals for Jewelry During 1954

METAL	WEIGHT	PRICE	VALUE
*Gold	1,000,000 oz.	\$35 per oz. (Troy)	\$35,000,000
Platinum	37,749 oz.	\$90	3,400,000
Palladium	27,408 oz.	\$21	575,000
Iridium, rhodium ruthenium, osmium	5,689 oz.	\$115	655,000
*Silver	500,000 oz.	85c	425,000
*Copper	200,000 lb.	30c per lb.	60,000
*Nickel	500,000 lb.	65c per lb.	325,000

*Estimated



ever, in New Jersey an article may be marked "palladium" if it contains a minimum of 95% palladium; elsewhere the stamping position of this metal is not clearly defined.

The quality control system operates very simply. The manufacturers apply the quality marks themselves. Hitherto the industry has done its own policing through a Vigilance Committee. "Trade Practice Rules for the Jewelry Industry", recently issued by the Federal Trade Commission, will help further in maintaining standards.

Composition and Mechanical Properties

The composition and mechanical properties of some jewelry alloys are given in Table IV. This presentation is primarily for metallurgists, because jewelry manufacturers, in contrast to other metal fabricators, show little interest in detailed composition or mechanical test data for their alloys. They seek metals with adequate strength and hardness in the annealed condition, and with good ductility and solderability.

Platinum and palladium, like gold and silver, are too soft to be used as the pure metals and it is customary to alloy them

with other metals of the platinum group. Popular jewelry alloys include 95 platinum, 5 iridium; 90 platinum, 10 iridium; and 95.5 palladium, 4.5 ruthenium. Ordinary jewelry platinum (95%) and palladium (95%) in the annealed condition have tensile strengths from 40,000 to 50,000 psi, hardness of Brinell 85 to 90 and elongation of 25%.

Gold jewelry alloys are divided into colored golds and white golds. Alloying metals modify the natural yellow gold color of pure gold; copper gives a red shade, silver a green tone, and nickel, palladium and zinc have a whitening effect. The effect of composition on color can be seen in the 14-karat golds included in Table

Table III — Stamping Law Requirements for Composition of Jewelry Alloys

JEWELRY METAL	CONTENT	ALLOYING ELEMENTS
Silver, sterling	92.5%	Unspecified
Silver, coin	90.0	Unspecified
Gold, 18-karat	75.0	Unspecified
Gold, 14-karat	58.35	Unspecified
Gold, 12-karat	50.0	Unspecified
Gold, 10-karat	41.65	Unspecified
Platinum (if solder is not used)	93.5 to 98.5*	1.5% Unspecified
Platinum (if solder is used)	90.0 to 95.0*	Up to 3.5% solder; 1.5% Unspecified
Palladium	95.0†	Unspecified

*The range of permissible platinum content exists because up to 5% of platinum can be replaced by other metals of the platinum group — palladium, rhodium, iridium, ruthenium or osmium.

†Minimum content specified in the New Jersey Stamping Law.



IV. Yellow is the most popular of the colored golds; there are several 14-karat yellow golds, a typical one having the composition 58.3% gold, 10.4% silver, 29.1% copper and 2.1% zinc. The other colored golds, which are used to get special decorative effects, are of relatively minor importance. The lower quality golds (10 and 12 karat) are used for making gold filled and rolled gold plate articles. Colored golds in the annealed condition have tensile strengths from 60,000 to 80,000 psi, hardness numbers from Brinell 85 to 180, and 30 to 50% elongation. White golds are almost as popular as yellow gold in some areas. The usual white gold is a quaternary alloy containing nickel, zinc and copper, which is substantially stronger and harder than

yellow gold. Its tensile strength is about 100,000 psi., hardness Brinell 200 to 250, and elongation about 45%. Palladium-containing white gold has been used for hand-made jewelry, but can never be popular because it costs more than the other white golds of the same karat; it lacks the strength and hardness of the nickel-containing white gold. It has a higher melting point and is preferred where much soldering has to be done.

There is little, if any, systematic metallurgical control in the manufacture of jewelry, although the primary fabrication by the refiners is carefully controlled. The manufacturer relies on traditional methods with occasional advice from the refiners who supply his metals. Wherever

Table IV — Composition and Mechanical Properties of Jewelry Alloys*

METAL	AU	AG	CU	Ni	ZN	OTHER	TENSILE STRENGTH	ELONG. IN 2 IN.	BRINELL HARDNESS
Platinum, 95.0%	—	—	—	—	—	5 Ir	40,000 psi.	25%	90
Platinum, hard, 90.0%	—	—	—	—	—	10 Ir	55,000	25	130
Palladium, 95.5%	—	—	—	—	—	4.5 Ru	54,000	25	85
Colored golds									
18-karat yellow	75.0	15.0	10.0	—	—	—	67,000	42	125
14-karat red	58.3	—	41.7	—	—	—	57,000	50	85
14-karat pink	58.3	4.9	31.6	5.2	—	—	82,600	42	170
14-karat yellow	58.3	20.8	20.8	—	—	—	77,000	34	180
14-karat yellow	58.3	10.4	29.1	—	2.1	—	—	40	—
14-karat green	58.3	30.0	6.0	1.5	4.2	0.1 Mn	80,400	32	—
10-karat yellow	38.5	15.4	41.9	1.2	3.1	—	83,300	34	—
10-karat yellow	41.2	8.8	42.1	1.6	5.8	—	—	—	110
White golds									
18-karat	75.0	—	3.5	16.5	5.0	—	100,800	47	245
18-karat	75.0	—	—	—	—	25 Pd	44,000	—	76
14-karat	58.3	—	16.0	17.0	8.6	—	105,000	43	206
Silver									
Sterling	—	92.5	7.5	—	—	—	37,400	42	50
Coin	—	90.0	10.0	—	—	—	40,000	—	60

*Mechanical properties are approximate values in the annealed condition.

possible full advantage is taken of work hardening to improve wear properties, but where soldering has to be done at a later stage there will be local annealing. Metallurgically the gold alloys are interesting because many of them are age hardenable by a mechanism depending on the arrangement of gold and copper atoms. Although this property of the gold-copper alloys has been utilized in the dental field for more than 50 years, few jewelers appear to have felt a need to increase the strength and hardness of their metals by age hardening. Actually the demand for hard jewelry metals is relatively small because mechanisms, springs, and other internal parts do not have to conform to Stamping Laws and consequently are made of base metals. Although age hardening would be possible for certain articles, it obviously would not be applicable to articles set with precious stones.

Both the workability of palladium and its suitability for *objets d'art* are well demonstrated by the Baker Palladium Perpetual Trophy for the International Grand Prix Power Boat Race, shown alongside.

[In subsequent articles, Mr. Atkinson will discuss other aspects of precious metal jewelry manufacture. Among the subjects to be covered are special fabricating techniques and precision casting methods.]

This palladium trophy required the use of many of the jeweler's arts and techniques. (Courtesy International Nickel Co.)





Corrosion Test Sites Needed

WILMINGTON, DEL.

A task group of the Welding Research Council (High Alloys Committee), has undertaken a field corrosion test program to determine what industrial plant mediums are specific in causing intergranular corrosion of stainless steel. Intergranular corrosion in both wrought and cast steels is sometimes called "sugaring" because whole grains can be rubbed from the surface; when present adjacent to welds, it is known as "weld decay".

It is well known that unstabilized austenitic stainless steels such as Types 304 and 316 can be rendered susceptible to intergranular attack by heating into the range of 900 to 1400° F. This susceptibility has been related to carbide precipitation and can be brought about by exposure in this temperature range for times as short as those encountered in welding (seconds).

Susceptibility to intergranular corrosion can be appraised by exposure in such test mediums as boiling 65% nitric acid, acidified copper sulphate solution, and a mixture of nitric and hydrofluoric acids. These tests can often predict whether or not specific lots of steel may be intergranularly corroded if installed under service conditions which are known to produce this type of attack. The present program is aimed at obtaining more information on the character of process mediums which will cause this type of attack.

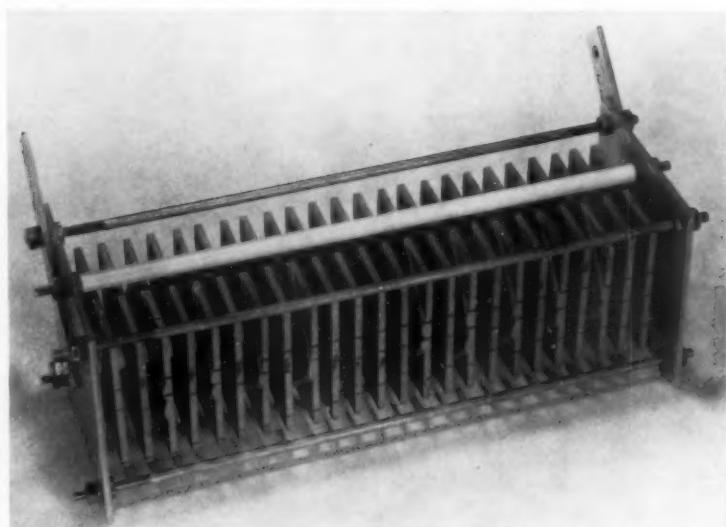


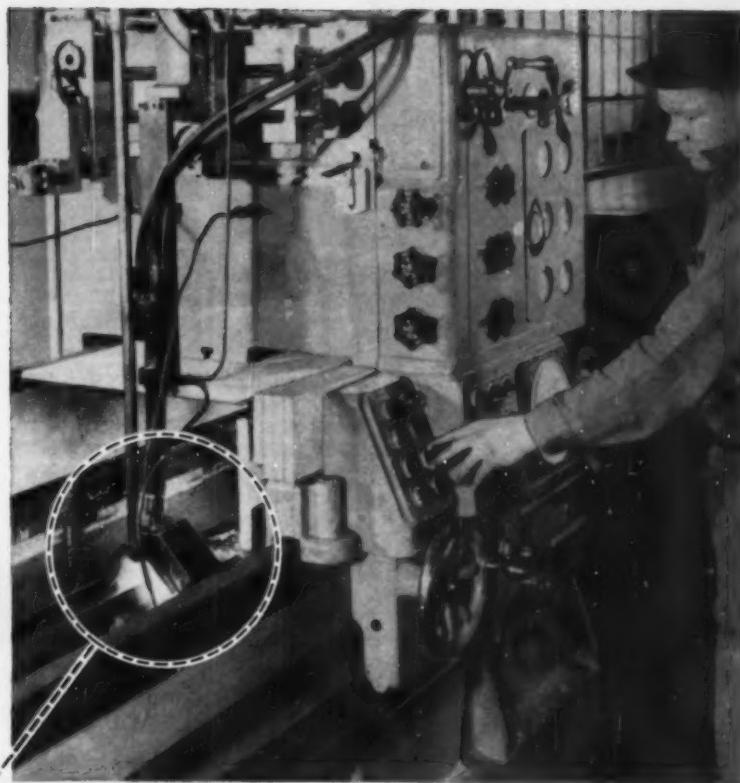
Fig. 1 — Test Rack Containing 20 Specimens of Type 304 or 316 Stainless

Included in the list of commonly encountered mediums known to cause intergranular corrosion of susceptible steels are sulphuric, acetic, formic, and some of the fatty acids, in addition to the test solutions listed above. A fairly wide area of ignorance exists concerning other solutions which might cause this type of attack. In approaching new problems, therefore, the user of the steels has two choices. The first involves "taking a chance" and gambling that intergranular corrosion will not occur in plant equipment assembled in the conventional manner. The price of this approach is possible plant shutdown, lost production, and equipment replacement. The second alternative is to "play it safe" and pay a premium for stabilized or low-carbon alloys. This

premium is reflected directly in plant investment.

To partially close this gap, the task group has prepared several hundred corrosion test racks for exposure under a wide variety of conditions and locations. Two series of racks have been prepared as illustrated in Fig. 1, one series carrying specimens of Type 304 stainless steel and the other Type 316. The racks carry approximately 20 specimens each, which represent the range of intergranular corrosion susceptibility from the fully annealed condition through partially and severe sensitization as caused by conventional welding and stress-relieving heat treatments. Welded specimens, Fig. 2, include "as deposited" weld beads prepared at several welding heats as well as

HIGH SPEED FLAME- HARDENING



SPECIAL MACHINE UPS LIFE OF GRAPHITIC STEEL PARTS

LINDE engineers have assisted Cincinnati Steel Treating Company in developing a flame hardening machine which increases service life of 16 ft. long, graphitic carbon steel lathe ways . . . Development of this automatic, high speed machine is another example of how LINDE Service Engineers are helping LINDE's customers up production speed and unit quality through co-operative research engineering.

With this new machine, a lathe way to be treated is placed on a magnetic chuck in a water filled channel. Flame-hardening heads and control mechanism move at predetermined speeds along the part. After it cools, the lathe way is placed in a refrigerator for 24 hours which stabilizes the steel, and brings its case hardness to a minimum of 60 Rockwell "C" scale.

The benefits of LINDE's research, engineering, and over 40 years of accumulated know-how stand behind each of its customers to help them solve production problems. Get these "plus-values" which LINDE offers—it pays you to do business with LINDE.

Cross-section view shows uniform depth of hardened surface.

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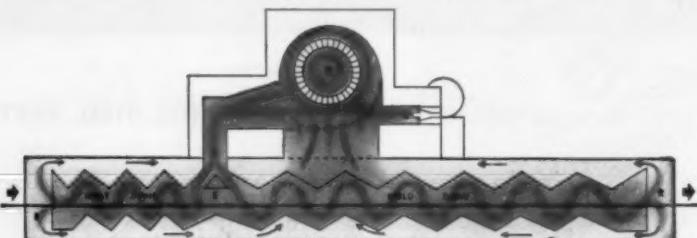


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Hot gases from the combustion chamber "C" and recirculated gases returning from the work chamber mix in the fan area "F." Entering the heating area through "T" at control temperature, balanced heat is directed to the charge and discharge ends, and is returned to the mixing chamber. The continuous V construction of the metal liner forces the hot gases up and down through the load at high velocity. The hot gases in the heating zone flow counter to the work. Heat transfer is rapid. Equilibrium is reached at point "E", and $\pm 5^{\circ}$ F. is held the length of the holding zone. Heating is without temperature head.

"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour.

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PIONEERS AND STILL LEADERS IN RECIRCULATION

Corrosion Testing . . .

some welds that have been stress-relieved. The specimens have been carefully heat treated and tested in standard corrosion test mediums, and their pedigrees recorded.

A search for test sites is now in progress. Exposure locations are desired where the racks (which are approximately 6 \times 12 in.) can be

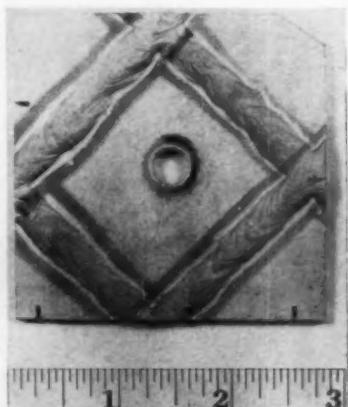


Fig. 2 — Welded Specimen, Ready for Insertion in the Test Rack

securely fastened in the process medium. Exposure conditions should remain reasonably constant for at least a year. Those interested in cooperating in this program are invited to submit a description of the exposure site including the solution composition and local exposure conditions. Specific process details are not necessary. If and when results are published, appropriate acknowledgment will be made.

This program should make it possible to spell out more adequately the characteristics of process mediums which will cause intergranular corrosion, and what level of resistance to this type of attack, as measured by conventional tests, is necessary for effective utilization of the austenitic stainless steels.

Those interested in cooperating in this project should write to the chairman of the task group, as shown below.

W. B. DELONG
E. I. duPont de Nemours & Co., Inc.

Engineering Dept.,
Experimental Station,
Wilmington 98, Del.

(More correspondence on p. 116)

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.



Ultra-Strength Steels Boost Tensile Strengths to 300,000 psi.

Ten years ago, engineers considered 180,000-psi tensile strength in steels the maximum they could use safely.

Today, alloy steels with minimum strengths of 220,000 to 300,000 psi are being used commercially. These ultra-strength steels have the ductility and toughness needed for structural applications. At tensile strengths above 220,000 psi, they show more strength per pound of product than high-strength aluminum alloys. And at 260,000 psi, they are approximately 15% lighter than aluminum alloy products of the same strength.

Molybdenum is an essential element in almost all of these steels.

How are the higher strengths and

strength/weight ratios of these steels being used? Until recently, they've been utilized almost exclusively in aircraft components, such as landing gear. Now, however, they're being considered wherever weight and space savings compensate for higher fabrication costs . . . as, for example, in equipment that must be moved (portable tools); gears, pulleys, belts, liners; heavy machinery operating at high stresses; machinery where inertia is a design factor; materials-handling equipment, such as cranes; and transportation equipment.

Like to know more about ultra-strength steels and their properties, and the names of manufacturers? For our free booklet, circle #1 on the coupon.

Bulletin Shows How to Get Heat Resistance in Cast Iron

In cast iron, heat resistance can mean different things: resistance to growth, to heat checking, to scaling, or to deformation under load at high temperatures.

"Why Moly Iron? #5" contains a chart showing the specific kinds of heat resistance needed by parts such as brake drums, melting pots, piston rings and so on. This chart also lists the best type of iron to use and the proper alloy additions. A number of detailed case histories document this useful bulletin.

For a free copy of "Why Moly Iron? #5" circle #2.

New Coatings May Solve Moly's Oxidation Problem

The most important obstacle to using molybdenum at high temperatures is being overcome. Oxidation is the problem; at temperatures over 1000°F, molybdenum oxidizes rapidly.

Newly developed coatings offer molybdenum the needed protection. Three types are promising:

1. Electro-deposited chromium and nickel layers which protect molybdenum to 2000°F.

2. Sprayed coatings of aluminum-chromium-silicon alloys, and nickel-boron alloys, which have proved effective at 2000-2400°F.

3. Ceramic and molybdenum disilicide coatings which hold promise of protecting molybdenum from oxidation at even higher temperatures.

Digested from "Protecting Molybdenum at High Temperatures" by Julius Harwood, Materials & Methods. For reprint of entire article, circle #3.

Booklet Deals with Molybdenum Joining Techniques

Recent progress in joining molybdenum, and suitable means for protecting it from oxidation, are opening up new uses for molybdenum and its alloys in structural components for high-temperature service.

"A New Look at Joining Molybdenum" by R. R. Freeman and J. Z. Briggs, both of Climax, analyzes the factors involved in joining moly and discusses the methods available.

For the free booklet, circle #4.

List of Moly Literature Now Available

Copies of more than 30 recent pieces of technical literature on molybdenum are available from Climax Molybdenum Company. For a free list of these, including titles, authors, sources and 25-30 word summaries, just circle #5.

Steels for Power-Plant, Refinery Equipment at 900-1100°F

Designers of power-plant and refinery equipment who need to select steels for applications at 900 to 1100°F will be interested in a copy of "Chromium-Molybdenum and Chromium-Molybdenum Vanadium Steels for power-plant and refinery service up to 1100°F."

This paper, presented at the ASME annual meeting by George V. Smith, Bard Professor, Cornell University, appraises literature on the subject and draws some new, objective conclusions.

For a free reprint, circle #6.

New Climax Alloy Proves Unusually Wear Resistant



These liner castings, made of Climax 321, proved highly resistant to wear in our ball mill discharge launders. Severe wear normally occurs in this operation as a result of erosion from the coarse pulp flowing out of the ball mill discharge.

If you need a highly wear-resistant material, you may be interested in our new Climax 321 Alloy. It's a hard, martensitic type of white iron containing nickel, chromium and molybdenum in proportions that are well balanced, both metallurgically and economically.

We've been using 321 Alloy in our own mining operations with exceptional results. Comparative tests in ball mill liners and grinding balls proved its excellent wear-resisting properties.

Because this alloy is relatively new, service results in other applications are not yet available. However, our laboratory studies and data indicate it should prove suitable for the general run of abrasion-resistant castings of the martensitic white iron type—such as wear shoes, sand and dredge pump wearing parts, pug mill knives, mixer liners, etc.

Climax 321 can be melted in a cupola or electric furnace and cast in either sand or permanent (chill) molds. It has a normal hardness range of 55 to 62 Rockwell "C".

Composition: Carbon 3.30-3.60%; Silicon 0.30-0.60; Manganese 0.50-0.80; Nickel 2.75-3.25; Chromium 1.75-2.25; Molybdenum 0.70-1.10; Sulphur 0.15 max.; Phosphorus 0.30 max. For data sheet, circle #7.

Climax Molybdenum Company, Dept. S
500 Fifth Avenue, New York 36, N. Y.

I'd like more information on:

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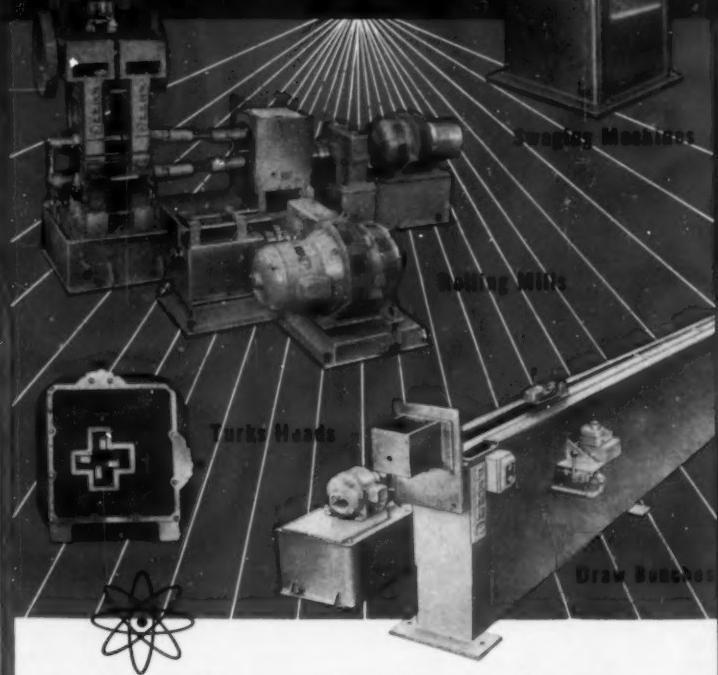
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Termites in the Lattice

MELBOURNE, AUSTRALIA

We have often tried to convince newcomers to the science of metallurgy that the weakness of metal components under some conditions is caused by termites in the lattice. Indeed, some failures appear to be explicable in no other way. However, it was not until we applied the technique of multiple-beam interferometry to the problem that we



A Multiple-Beam Interferogram of Electropolished High-Purity Aluminum. 150 X

were able to actually see one of these destructive little beasts in some super-purity aluminum. Under normal illumination all that could be seen was a pit which we had erroneously attributed to faulty electropolishing. As the illustration shows, this was obviously a burrow which the *termes metallurgica* was making.

R. C. GIFFINS
Physical Metallurgy Section
Commonwealth Scientific and
Industrial Research Organization

Effect of Lead on Steels

(Confession of Error)

In digesting an article on the above topic by W. E. Bardgett, research manager of the United Steel Companies Ltd. of England, George F. Comstock, our reviewer, wrote:

"Satisfactory service has been rendered by leaded steel in motor cars, etc., because the conditions of very high tensile strength with absence of notches (where lead is appreciably detrimental to fatigue



At the viewer examining a radiograph of a large impeller fan are Mr. Edward Young, Supervisor of Quality Controls (seated), and Mr. Russell H. Hollister, Vice-President, Sales, Morris Bean & Company.

"Inspection of our intricate aluminum castings needs the latitude of DuPont x-ray film"

says Mr. Edward T. Young, Supervisor of Quality Controls, Morris Bean & Company, Yellow Springs, Ohio



In the x-ray room at Morris Bean's foundry, Du Pont Technical Representative, E. R. Baron, discusses a typically intricate Antioch Process casting with Alfred C. Brightman, radiographer.

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"Furthermore," concludes Mr. Young, "all problems in both supply and use of the film are given prompt attention by the DuPont Technical Representative. This kind of service means a great deal to us."

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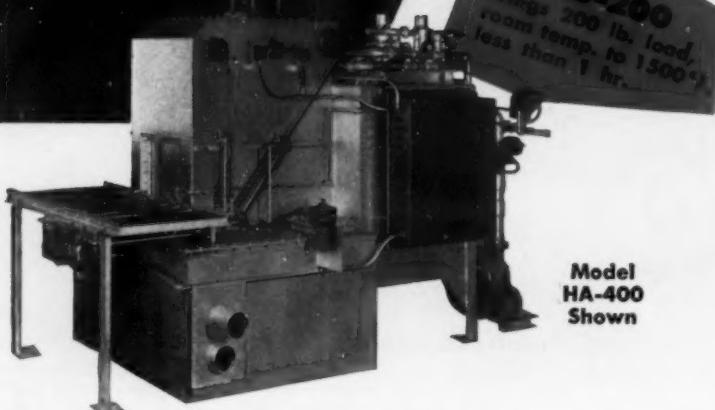


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Lead in Steel . . .

resistance) very rarely occur in engineering practice."

This was intended to summarize Mr. Bardgett's conclusion, which was:

"It would seem, therefore, that the conclusions go far to explain why, in spite of some past misgivings in respect of the fatigue properties of lead-treated alloy steels, thousands of tons of such steels have already given very satisfactory service in motor car and other components. Only at high levels of tensile strength, and where no stress raiser is present, does the presence of lead give rise to any substantial lowering of the rotary bending fatigue strength of these alloy steels, and very rarely is it that such conditions arise in engineering practice."

Unfortunately in editing the digest, both Mr. Bardgett and Mr. Comstock were made to say something quite incorrect, namely:

"Satisfactory service has been rendered by leaded steel in motor cars, because of the absence of notches in high tensile strength steel."

Mr. Bardgett in a recent letter to the Editor points out again that actually, lead has no effect on the values of limiting fatigue stress in the presence of a notch at the various tensile levels investigated, and only at high levels of tensile strength, and where no stress raiser is present, does the presence of lead give rise to any substantial lowering of the rotary bending fatigue strength of the alloy steels tested, and very rarely is it that such conditions arise in engineering practice.



Correction

In a book review entitled "The Metallurgy of Zirconium", (July 1957, p. 77), *Metal Progress* erroneously stated "The Metallurgy of zirconium is approximately 2 years old." This should have read "'The Metallurgy of Zirconium' [title of the book] is approximately 2 years old." Since there are several references in Mr. Goldman's review to the use of zirconium some years ago it is presumed that the readers will have recognized the above as a regrettable typographical error.

**This alloy
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saves many
a day for
busy
metallurgists!**

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303	414	5334
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308	420	5351
309	430	5352
309 + W	430F	5354
310	431	5355
316	431A	5358
321	436	5360
327	440A	5361
329	440B	5362
330	440C	5363
331	440F	5366
347	442	5369
403	446	5370
406		5372
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		5393
		6270F
		5394
		6274F
		5526
		6280C
		5537
		6350
		5610E
		6382
		5616
		6428
		5621
		7834
		5628
		5630
		51420
		70310
		51430
		70310A
		51431
		70327
		51440A
		70330
		51440B
		70331
		51440C
		70446
		51440F

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Personal Mention



Ted Du Mond



Henry H. Hausner

TED DU MOND is the newest member of the rapidly expanding staff of the Metals Engineering Institute. Mr. Du Mond will act as editor-in-chief of the educational courses prepared by the Metals Engineering Institute and, in addition, will be secretary of the Special Engineering Program Committee. As secretary, he will be responsible for all engineering and production sessions presented before regional and national meetings of the American Society for Metals, with the exception of the technical sessions at the National Convention, where the *Transactions* papers are presented.

A graduate of the University of Cincinnati, Mr. Du Mond has devoted his time primarily to the field of technical writing and editing, specializing in engineering materials. After a few years with the technical editorial service of Westinghouse Electric Corp. and in the sales department of George Gorton Machine Co., he joined McGraw-Hill Publishing Co. in 1940. In 1945 he became editor of *Materials and Methods*, and held this position until joining the staff.

Mr. Du Mond is an active member of many technical societies, in addition to the American Society for Metals, and has appeared as guest speaker at many local chapter meetings. He is the author of two books and more than 100 technical articles.

HENRY H. HAUSNER internationally known for his work in powder metallurgy and nuclear engineering, is continuing his pioneering work on powder metallurgy as vice-president of the nuclear engineering division of Penn-Texas Corp., New York City, and has started a program on research and development of the metal powder slip casting process, under an Atomic Energy Commission contract.

He received his metallurgical education in Vienna and later took charge of the laboratory of Elix A. G. there, one of Austria's leading incandescent lamp factories. As a result of his work with tungsten wire in lamps and electronic tubes, his interest was particularly focused on the fabrication and recrystallization of tungsten and molybdenum.

Immigrating to America in 1940, he worked with American Electro Metal Corp. for three years and then joined General Ceramics and Steatite Corp. as chief engineer. Here he attempted to combine ceramics and metals, and as a result published one of the first papers on "cermets". Turning from cermets to powder metallurgy, he investigated the powder metallurgy of reactor metals at Sylvania Electric Products Corp., in Bayside, L.I., until coming to Penn-Texas.

Dr. Hausner also finds time to act as adjunct professor at the Polytechnic Institute of Brooklyn and as consultant to several firms both here

and abroad, including Argonne National Laboratory. He has also just edited a new book, "Powder Metallurgy in Nuclear Engineering". He is active in technical societies not only in this country but abroad as well, and only last year was elected vice-president of the International Plansee Society for Powder Metallurgy of Reutte, Austria.

T. E. OLSON has formed the T. E. Olson Co. in Birmingham, Mich., to provide metallurgical and engineering sales representation to industry in Michigan. For the past ten years, Mr. Olson has been a sales representative with the Tocco Div. of the Ohio Crankshaft Co. He served as chairman of the Detroit Chapter in 1953.

Adolph J. Lena has been promoted to the newly created position of manager of the basic research department, Allegheny Ludlum Steel Corp., Brackenridge, Pa. Before his new assignment, Dr. Lena was associate director of research in charge of the physical metallurgy section.

Jay DeEulis has joined the industrial public relations firm of National Editorial Services as full partner and editorial director. For the past five years, Mr. DeEulis directed press relations and publicity activities as manager of press relations for the Carboloy Dept. of General Electric Co. in Detroit. He has also served as engineering editor of *Steel* and editor of *New Equipment Digest*, both published in Cleveland.

Thomas I. McClintock has been transferred from the Pittsburgh plant of the Aluminum Co. of America to the Alcoa plant at Vernon, Calif., where he will work under Roy E. Paine , past chairman of the Los Angeles Chapter .

Harry M. Alworth, Jr., has accepted a job as technologist in the sheet products division of the Applied Research Laboratory, U.S. Steel Corp., Monroeville, Pa. Mr. Alworth, a 1950 graduate of the University of Pittsburgh, was a metallurgist at the Gary, Ind., plant of the National Tube Div. of U.S. Steel before transferring to the Monroeville Laboratory.

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...says **Capital Airlines**



Capital Airlines, operators of the Viscount—America's first commercial prop-jet airplane—finds that the more modern the aircraft, the greater the need for precise quality control and inspection standards. Capital employs a production-line Dy-Chek® flaw location installation to inspect critical engine parts during engine overhaul. "We find that Dy-Chek not only contributes to passenger safety and ease of inspection," says Harold Ingalls, Superintendent of Maintenance and Overhaul of Capital, "but we also feel that it helps the 'vibrationless Viscount' give its passengers the smoothest airplane ride in the world."

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Title _____

Mr.

WORLDS LARGEST STOCK 52100 STEEL **Peterson** STEELS, INC.

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Personals . . .

Earl W. Coleman  is serving in the U.S. Navy for six months on the critical skills program. He is now stationed at Anacosta Naval Receiving Station, Washington, D.C., in the Naval Research Laboratory.

John T. Milek , formerly senior research engineer for North American Aviation, Inc., is now with Litton Industries, Beverly Hills, Calif., working on materials and process engineering as applied to manufacture of electronics components.

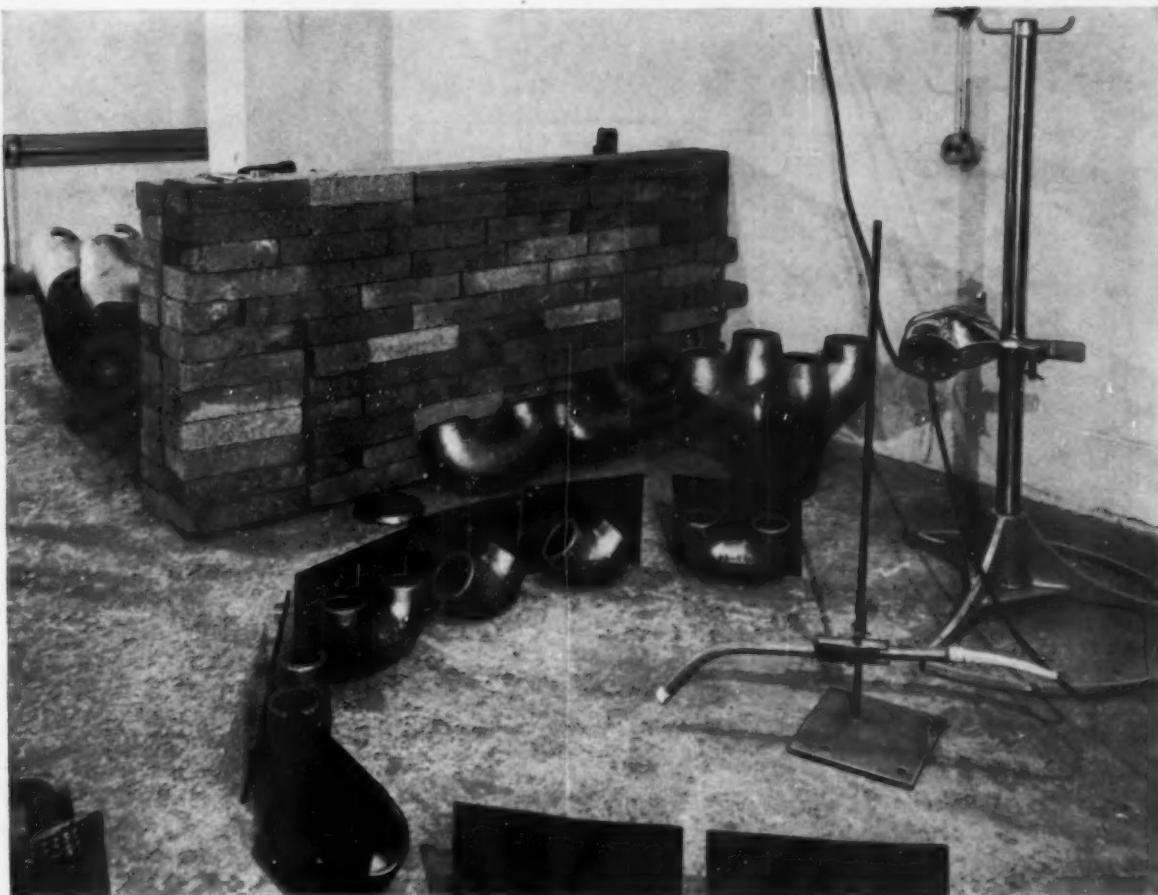
John W. Buskie  has been elected vice-president of Tennessee Products & Chemical Corp., Nashville, Tenn., a division of Merritt-Chapman & Scott Corp. Mr. Buskie joined the company in 1954, and since 1955 has served as vice-president of a subsidiary, Tenn-Tex Alloy & Chemical Corp. More recently, he was named assistant vice-president of Tennessee Products & Chemical Corp.

Samuel E. Tyson  has been appointed metallurgist, stainless steels, for the Carpenter Steel Co., Reading, Pa. Mr. Tyson began his career at Carpenter as a laboratory assistant after his graduation from Pennsylvania State University in 1948, and was promoted to assistant metallurgist, stainless steels, in 1955.

W. B. Jones  has been promoted to the post of sales manager, agricultural products, for the Crucible Steel Co. of America, Pittsburgh. For the past five years, Mr. Jones had been supervisor of agricultural sales at the company's Chicago sales branch, and prior to that time had been a sales service engineer at the Chicago branch.

Walter H. Langford  has been transferred to the Longview Tex., installation of R. G. LeTourneau, Inc., as director of metallurgy. Mr. Langford, who joined LeTourneau in 1938, was formerly assigned to the Vicksburg, Miss., plant.

Harry B. Burrack  has been named technical superintendent of the new Olin Mathieson Chemical Corp. aluminum plant in Monroe County, W. Va. Mr. Burrack, who has had 20 years experience in various phases of the aluminum industry, joined Olin Mathieson in 1955.



OHIO STEEL FOUNDRY CUTS COSTS MORE THAN 50% WITH NUCLEAR SYSTEMS' RADIOGRAPHY MACHINES

Art Gross, chief metallurgist of Ohio Steel Foundry Co., Springfield, Ohio, states that by using two radiography machines designed and manufactured by Nuclear Systems, a division of The Budd Company, approximately 3000 "shots" a month are made in testing castings of various sizes and shapes.

"By exposing a number of castings at one time," said Mr. Gross, "Ohio Steel has cut operating costs to less than half of what we'd spend if we used X-ray equipment. Also, if we used X-ray, we'd require 50% more people on the job to maintain safety from exposure."

"Using Nuclear Systems' models 10 (shown above) and 50, we keep the machines in use 24 hours a day checking production fittings such as valves, elbows and tees. To control quality we radiograph about 10% of this type equipment."

Nuclear Systems manufactures a complete line of gamma radiography machines for all industrial requirements.



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increase uniformity, speed production

By providing continuous movement through heat treating cycles, woven wire conveyor belts eliminate batch handling, increase product uniformity and production capacity in annealing, brazing, quenching, tempering, sintering, etc. EXAMPLE:

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OPEN MESH of Cambridge belt allows free circulation of heat around load so that hot spots are eliminated. Open mesh construction also permits rapid drainage in wet processes such as quenching and washing.

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SPECIAL RAISED EDGES hold parts on belt, are typical of a variety of side and surface attachments available to hold the product during flat or inclined movement.

Cambridge Woven Wire Conveyor Belts are made in any size, mesh or weave, from any metal or alloy, and can be used under a wide range of conditions . . . hot or cold, wet or dry. Call your Cambridge Field Engineer to discuss how you can cut costs with continuous processing on woven wire conveyor belts. Look for his phone number under "Belting, Mechanical" in the Yellow Pages or write for FREE 130-PAGE REFERENCE MANUAL.



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Personals . . .

R. B. McCarthy has been appointed chief engineer of the steel mill division of Surface Combustion Corp., Toledo, Ohio. A member of the company for nine years, Mr. McCarthy's early experience with the corporation was in the erection department working on the operation and construction of all types of steel mill equipment. Until taking over his new assignment, he was assistant chief engineer.

Raymond A. Barry , formerly chief chemist of Electric Auto-Lite Co., Cincinnati, Ohio, was recently appointed a sales engineer for the Cincinnati district by Wagner Brothers, Inc., Detroit.

Gerald Abowitz , recently released from the Corps of Engineers, U. S. Army, is attending Yale University as a General Electric Co. Fellow in metallurgy, studying for his doctorate degree in engineering.

Donald F. Stoneburner is undertaking full-time graduate study at the Carnegie Institute of Technology as a Union Carbide Corp. Fellow, working toward a Ph.D. degree in metallurgical engineering. During this time he will be on a leave-of-absence from the Oak Ridge National Laboratory where he is currently employed as an associate metallurgist.

Richard B. Gordon has resigned as manager, core engineering department, at the Bettis atomic power division of Westinghouse Electric Corp. to accept a position as nuclear specialist in the Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

J. William Robinson has been named president of the newly organized Leeds & Northrup, Canada, Ltd., Toronto, a wholly owned subsidiary of Leeds & Northrup Co., Philadelphia. The new firm will manufacture and distribute the electronic controls and measuring instruments formerly supplied from the United States. The production manager and assistant secretary for the company is J. Robert Gowen . Both Mr. Robinson and Mr. Gowen were formerly concerned with the western operations of Leeds & Northrup which included Canada.



**USE FINKL DIE BLOCKS
FOR QUALITY FORGINGS...**

farm equipment manufacturers do!



International Harvester Company's Tractor Works, for one, uses Finkl die blocks to produce numerous tractor parts such as the pivot shaft bracket, pull hook, track link, equalizer spring saddle, and draw bar bracket shown on this page.

Because of the high volume production of these Crawler Tractor parts, Finkl FX die blocks are used at Harvester's Tractor Works to produce more forgings per sinking, and more sinkings per die. The special machining quality reduces die sinking time, without impairing the heat or wear resistance of the dies in production.

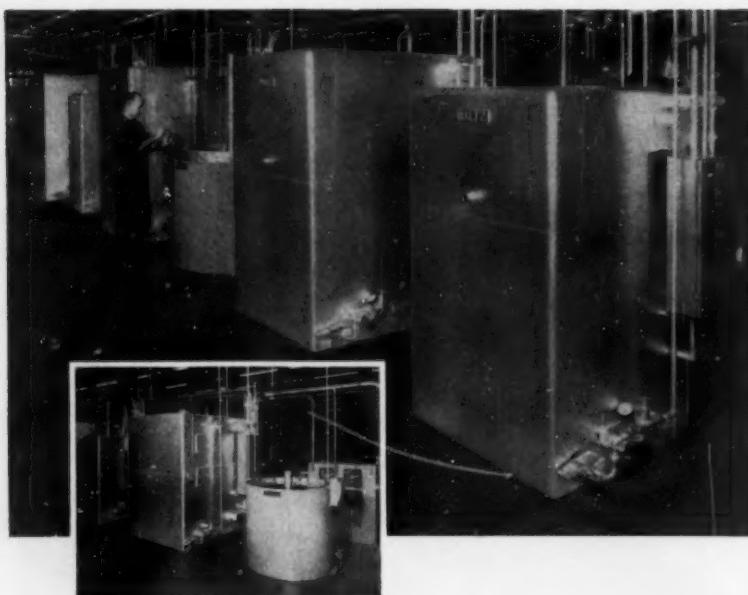
Finkl die blocks are available in several grades, all sizes, and tempers to handle virtually any forging requirement. Call your local Finkl representative next time you are considering die blocks or forgings. He will be glad to help you and there is no obligation.

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Waltz furnaces have the forward look

at Chrysler Corporation

When equipping Chrysler Corporation's new TorqueFlite automatic transmission plant at Kokomo, Indiana, Chrysler engineers demanded equipment capable of top performance. WALTZ Furnaces were selected for the automotive tool room.

In addition to delivering the performance required, Waltz Furnaces also are attractive, smooth, easy-to-clean. Outer shells reach all the way to the floor to prevent unsightly and dangerous clutter usually found under ordinary furnaces. Waltz doors fit flush and tight, are opened with a convenient foot pedal control. Cabinet-type control panels are neatly wired to terminal blocks for easy installation.

Performance-appeal? Waltz has plenty. Just try to match the amazing versatility of a Waltz furnace. Originally installed by Chrysler just to handle the needs of the automotive tool room, the furnaces shown in the illustration were soon called on to handle many pilot parts, as well as regular production runs. Chrysler stayed right on schedule. So can you!

A complete line of Waltz standard or special heat-treating furnaces, using all types of fuels, is built to suit your requirements. Write for comprehensive illustrated bulletins to Dept. W.

Choice Distributor Territories Now Open

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Personals . . .

Edgar W. Engle has been appointed development engineer for Kennametal, Inc., Latrobe, Pa., in connection with the company's current expansion program. Mr. Engle, formerly technical director for the Vascoloy-Ramet Corp., Waukegan, Ill., will be concerned with the development of new products.

F. H. Alviset is currently employed as chief engineer for Atlas Pipe Inc., Houston, Tex.

A. Dean Meyer has been named general manager of the Ajax Electrothermic Corp., Trenton, N.J., to succeed **Guilliam H. Clamer**. Mr. Meyer, who joined the company in 1929, has served the company as a vice-president since 1947 and more recently was named a director. Dr. Clamer had held the position of general manager since the formation of the company in 1920; he will continue to serve as president.

Louis V. Privoznik has accepted a position as supervisor of the manufacturing development laboratory with Westinghouse Electric Corp.'s steam division in Lester, Pa.

E. D. Cowlin has resigned after 33 years of continuous service with the Reliance Div., Easton Mfg. Co., Massillon, Ohio. Mr. Cowlin became manager of the New York district sales office of Reliance Mfg. Co. in 1924, and after Eaton acquired Reliance was appointed general sales manager and finally general manager of the division. He will be succeeded as general manager by **Chester A. Sellen**. Mr. Sellen had been assistant general manager and chief metallurgist of the division for the past three years.

Carl Ludwig has been made chief engineer of the engineered products division of the Wellman Engineering Co., Cleveland, an affiliate of the McDowell Co., Inc. Mr. Ludwig was added to Wellman Engineering's staff in 1956, and prior to that time was affiliated with the Rolling Mill Div. of Olin Mathieson and the Adamson Div. of Hydropress, Inc.

Matthias P. Rival is now chief plant engineer for the Fafnir Bearing Co., New Britain, Conn.

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Whether it's *versatility* you need—a single furnace that can handle any number of different heat treating jobs efficiently—or a *specialized* piece of equipment to do a single job to super-critical tolerances—Pacific's complete line gives you exactly the right one for your job!

The installations shown here are just a few of Pacific's "standard" furnace designs. In addition, modifications or completely custom designed furnaces can be built to your own specifications. A Pacific field engineer will be glad to discuss your heat treating problems or requirements—write today!



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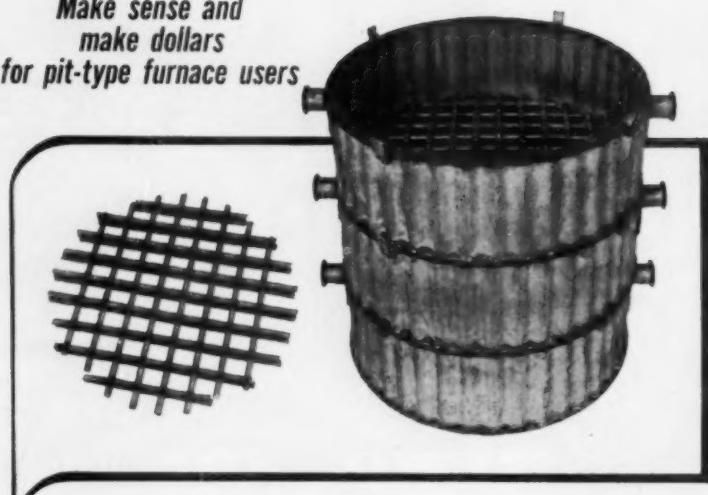
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**Make sense and
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ROLOCK'S unique CORRUGATED construction

with pressure-welded truss-type grids

There are many good reasons why these new furnace baskets out-perform and outlast older types. ROLOCK's Corrugated Construction gives high strength with light weight and this, in turn, means less material to bring up to temperature with faster, more uniform heat transfer . . . and a higher ratio of pay load to basket weight. Such baskets mean a substantial saving in furnace time because of faster recovery and, in some cases, an increase in average load as well.

ROLOCK's specialized Welded Fabrication takes full advantage of this construction in every respect. The grid, for example, is built up from rounds rather than flats by a ROLOCK-developed pressure-welding method. Experience shows that such grids are far better able to withstand thermal shock. They may be reversed as required, to compensate for deflection, without cracking.

In this field, as in many other specialized applications of welded-fabricated heat-resistant alloys, ROLOCK's exceptional facilities and skills often promise major operating savings. Write us outlining your problems.

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Personals . . .

Michael Ference, Jr., \ominus is currently director of the scientific laboratory, engineering staff, Ford Motor Co., replacing Dr. A. A. Kucher \ominus who was named vice-president, engineering and research, for the company.

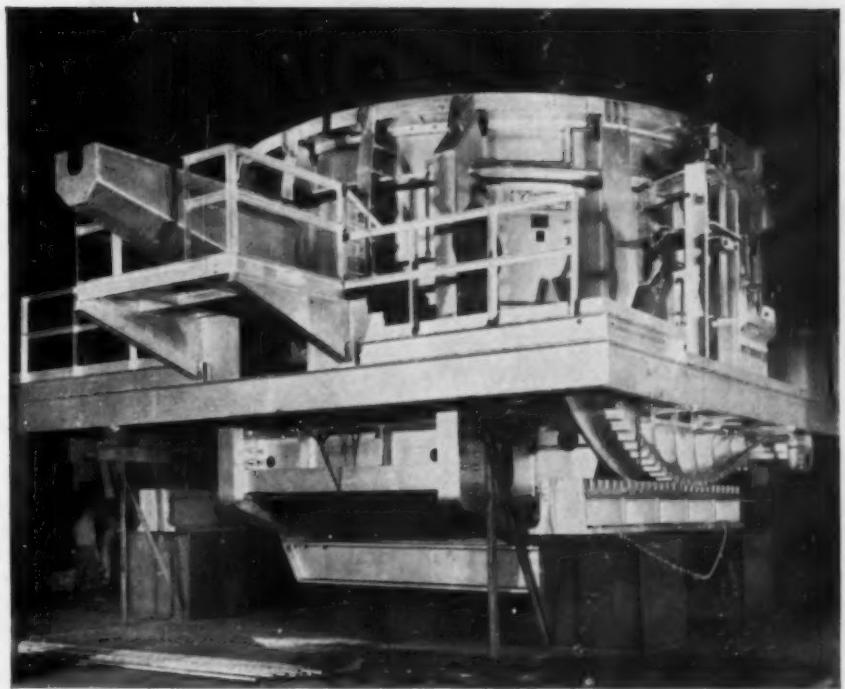
Sherwood W. McGee \ominus is now associate metallurgist with the Armour Research Foundation of Illinois Institute of Technology in Chicago, where he has been employed since his graduation from the University of Illinois in 1952.

John L. Cotsworth \ominus has been named staff manager, stainless steel, for Chase Brass & Copper Co., Waterbury, Conn. For the past year, Mr. Cotsworth was manager of sales for Northeastern Steel Corp. Bridgeport, Conn., and before that was on the sales staff of Atlas Steels, Ltd., Welland, Ont.

Kelvin Sproule \ominus has been transferred to the development and research division of the International Nickel Co., in New York, where he will be concerned with Inco's investigations on the use of atomic energy effects in research. Mr. Sproule had been a consulting metallurgist on the staff of the International Nickel Co. of Canada, Ltd., at Copper Cliff, Ont., and from 1948 to 1955 was superintendent of research for Inco of Canada.

Edwin R. Young \ominus has been named to the newly created position of employee counselor in the personnel department of the Norton Co., Worcester, Mass. Mr. Young has served the company for over twenty years in various supervisory positions.

Lee F. Weitzenkorn \ominus has been assigned the post of assistant to the works manager of Armco Steel Corp.'s Baltimore, Md., works. Formerly Armco's work metallurgist, Mr. Weitzenkorn will coordinate the steel works' quality control and develop improved processing procedures. At the same time, John S. White \ominus has been promoted to works metallurgist to succeed Mr. Weitzenkorn. Supervising metallurgist until this promotion, he will now be in charge of the metallurgical department.



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Rockers and tilting mechanism are out-from-under; won't get clogged by spillage or burn-throughs. Like all Lectromelt components, they're sturdy and strong.

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Consider, too, some of the other outstanding advantages of "SUPERCASE" over older nitriding methods . . . case depths are controlled to much finer limits . . . dimensional change is negligible . . . reworking, when needed, simply involves case removal, and selective hardening is easily accomplished by masking off areas that require machining after nitriding. Ask about "SUPERCASE" . . . write Standard for full details today!

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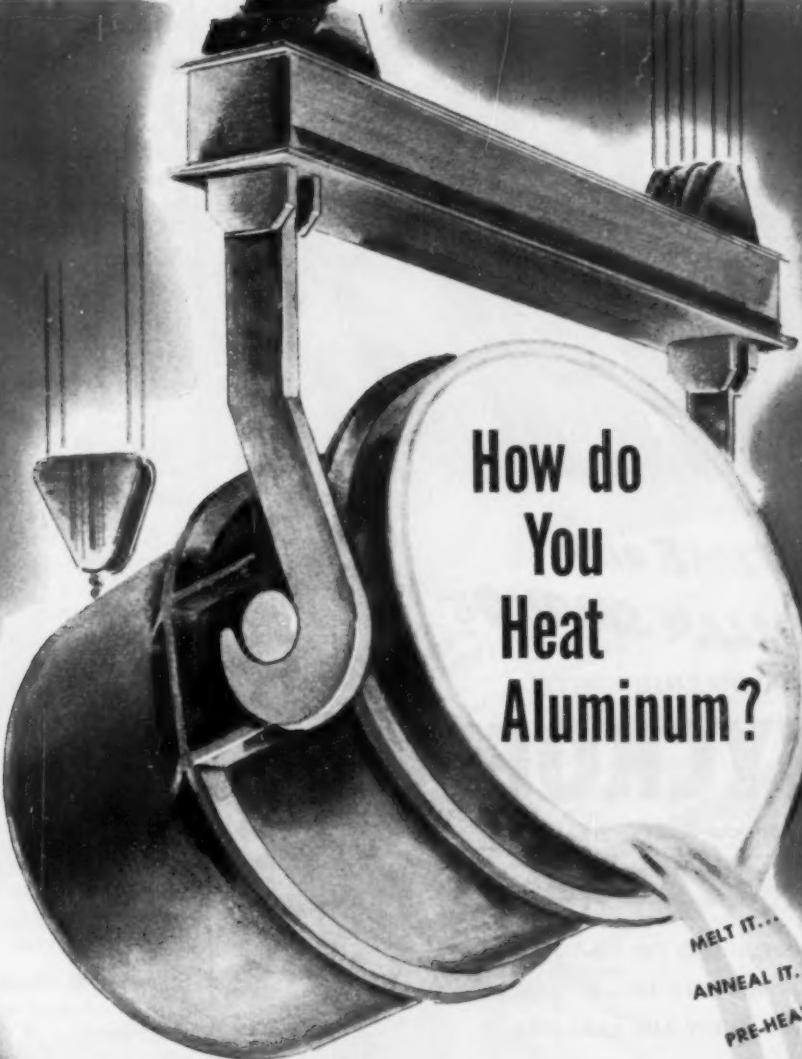
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Personals . . .

Stanislaus S. Thomas ☺ recently joined the reactor engineering division of Argonne National Laboratory in Lemont, Ill. Prior to joining the Laboratory, he was an assistant professor of mechanical engineering at the University of Notre Dame.

John Chipman ☺ has been nominated vice-president of the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers for 1958. The vice-president automatically assumes the office of president of the society in 1959. Dr. Chipman, a past president of A.S.M., is professor of metallurgy at Massachusetts Institute of Technology, where he has been teaching for 20 years. In addition, Carleton C. Long ☺ director of the research department, St. Joseph Lead Co., Monaca, Pa., Cyril Stanley Smith ☺, director of the Institute for the Study of Metals of the University of Chicago, James B. Austin ☺, vice-president, fundamental research, U.S. Steel Corp., Pittsburgh, J. S. Smart, Jr., ☺ assistant to the vice-president and director of research, American Smelting & Refining Co., Plainfield, N.J., Karl L. Fettlers ☺, assistant to the vice-president in charge of operations, Youngstown Sheet & Tube Co., Youngstown, Ohio, and Harold B. Emerick ☺, director, technical service, Jones & Laughlin Steel Corp., Pittsburgh, have all been nominated to the Metallurgical Society board of directors.

Arthur W. Thornton ☺ has been nominated by the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers as A.I.M.E. vice-president for one year. Mr. Thornton is assistant to the vice-president, operations, for National Tube Div. of U.S. Steel Corp., Pittsburgh. Joining the company in 1934, he has held his present position since 1954. Walter R. Hibbard ☺ is the Society's nomination for A.I.M.E. director. Mr. Hibbard, who is manager of alloy studies at the General Electric Research Laboratory, Schenectady, N.Y., is vice-president of the Metallurgical Society and will be its president next year.



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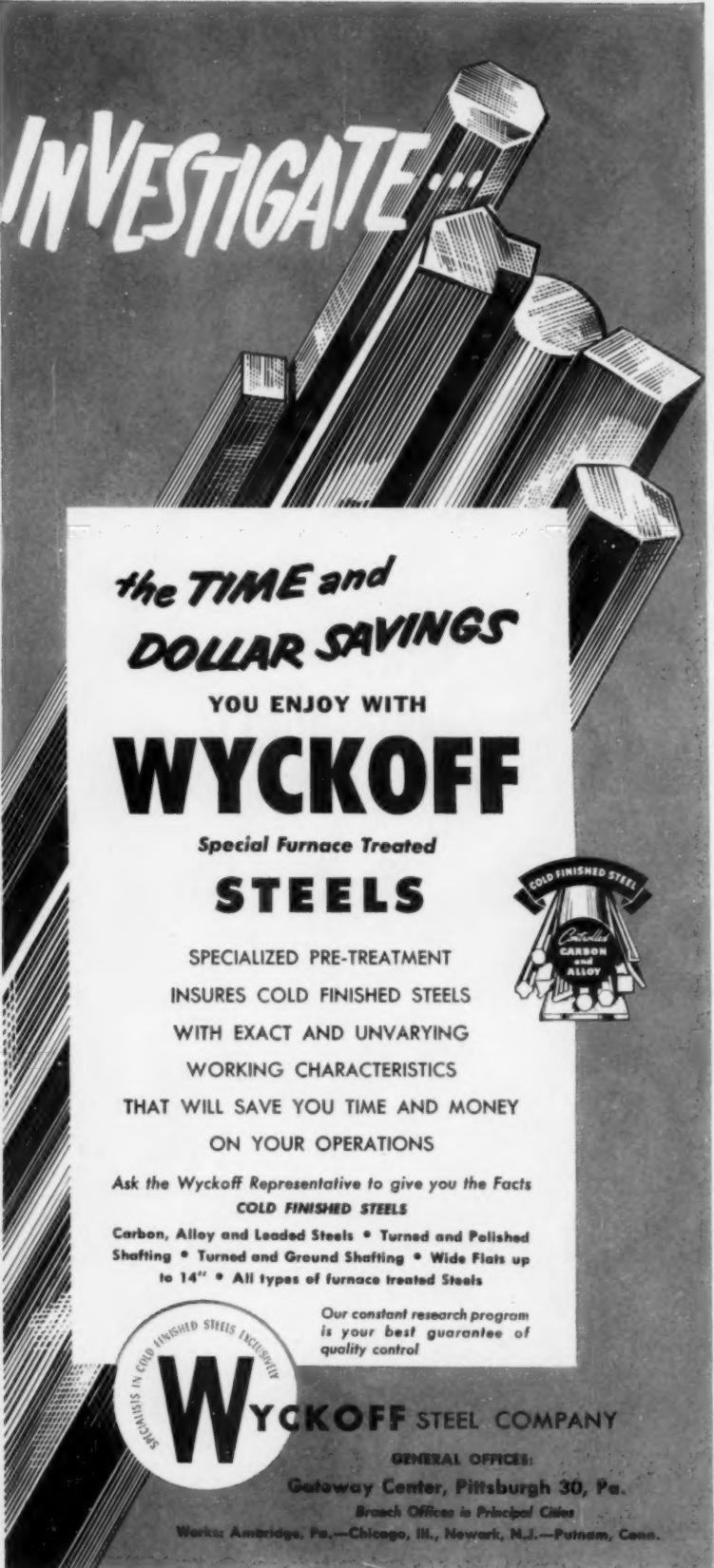
Personals . . .

L. A. Stoyell  has assumed new responsibilities as metallurgical engineer in charge of manufacturing for the new fine metals and chemicals division of the product and process department, Electro Metallurgical Corp., Niagara Falls, N. Y. This new division will be responsible for the manufacture and sales of new alloys, pure metals, and other new products. Mr. Stoyell joined Electromet in 1940 and has held a number of metallurgical research and engineering positions prior to his new appointment.

John S. Worth  and Thomas G. Foulkes  have been appointed metallurgical engineers at Bethlehem Steel Co., Bethlehem, Pa.

Wylie J. Childs  has been appointed visiting professor on the departmental staff of Rensselaer Polytechnic Institute. Dr. Childs, who has come to the Institute from Lafayette College, will devote his major effort to building up laboratory research and teaching in the general field of melting and solidification of metals. Allegheny Ludlum Steel Corp., Pittsburgh, has made a \$5,000 grant to the Institute toward the salary of a professor to lead study and research on the melting and solidification of metals, and Dr. Childs has been selected to receive this grant.

Several  members are among those nominated as officers in the three divisions of the Metallurgical Society of A.I.M.E.. Herbert H. Kellogg , professor in the School of Mines of Columbia University has been named chairman of the Extractive Metallurgy Div. In the Institute of Metals Div., Oscar T. Marzke of the Naval Research Laboratory in Washington, D.C., has been named senior vice-chairman and Prof. Thomas A. Reed of the University of Illinois has been nominated vice-chairman. George A. Roberts, Vanadium Alloys Steel Co., Latrobe, Pa., and David Swan, Electro Metallurgical Co., Niagara Falls, N.Y., have both been named to the executive committee of the division. Karl L. Fetter  is new chairman of the Iron and Steel Div. and Michael Tenenbaum , Inland Steel Co., East Chicago, Inc., is vice-chairman.



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THAT WILL SAVE YOU TIME AND MONEY
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Carbon, Alloy and Leaded Steels • Turned and Polished
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is your best guarantee of
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Yours for the asking!

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FOR HEAT AND CORROSION RESISTANT CASTINGS

Composition — per cent (balance Fe)

CAST ALLOY DESIGNATION	WROUGHT ALLOY TYPE (See Note A)	C	Mn max.	Si max.	P max.	S max.	Cr	Ni	Other Elements	
									Mo 0.5 max. [†]	Mo 0.5 max. [†]
CA-15	410	0.15 max.	1.00	1.50	0.04	0.04	11.5-14	1 max.	—	—
CA-40	420	0.20-0.40	1.00	1.50	0.04	0.04	11.5-14	1 max.	—	—
CB-30	431	0.30 max.	1.00	1.00	0.04	0.04	18-22	2 max.	—	—
CC-50	446	0.50 max.	1.00	1.00	0.04	0.04	28-30	4 max.	—	—
CB-30	—	0.30 max.	1.50	2.00	0.04	0.04	18-21	8-11	—	—
—	—	0.08 max.	1.50	2.00	0.04	0.04	18-21	8-11	—	—

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AND CHEMICAL COMPOSITION RANGES
FOR HEAT AND CORROSION RESISTANT CASTINGS

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Now...it's easy to remove even

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FINISHES**

**...with Oakite's NEW
STRIPPER S-A**

Did you think epoxy finishes next to "impossible" to remove? It was a tough job. That was before Oakite developed Stripper S. A. Here's what it has been doing:

- 1 A 3/16" thick coating built up from layers of epoxy coating and wrappings of fiber glass was stripped from gun barrels by Stripper S. A. by overnight soak. Everything tried previously had failed.**
- 2 Brass plated steel parts were stripped of their epoxy finish in a matter of minutes.**
- 3 Workholding spindles and racks laden with at least 10 coats were bared to metal by a short soak. Paint hooks formerly burned clean are now soaked clean instead.**

Oakite Stripper S. A. is safe for all metal surfaces except zinc and magnesium. This stripper needs no heat, has no flash point, rinses with water.

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Personals . . .

Lester E. Cooney () former district manager of the Chicago-Milwaukee-St. Louis sales territory, has become assistant to the vice-president in charge of sales for the Carpenter Steel Co., Reading, Pa. Mr. Cooney started with Carpenter in 1924, and has served as Chicago district manager for the past 16 years. At the same time, William J. Stephens () has been transferred from St. Louis branch manager to Chicago branch manager, and M. R. Gerhart (), sales representative in the Chicago area, has been named to succeed Mr. Stephens in St. Louis. Other appointments include Martin J. Holleran () who has been named district manager of the northern New Jersey territory and Donald F. Ross (), now assistant branch manager in the Dayton area.

Ralph J. Pukas () has become a member of the staff of the engineering department of Diamond Crystal Salt Co., St. Clair, Mich., where he will act as design engineer.

F. D. Illingworth () is currently district manager in charge of the New Jersey and New York State territory for A. Milne & Co., New York, operating from the company's new warehouse in Kenilworth, N. J.

Robert E. Renders () has established the Syracuse Metal Testing Laboratory in Syracuse, N. Y. to service foundries and fabricators in the central New York State area by providing chemical analysis, physical testing and a consulting service.

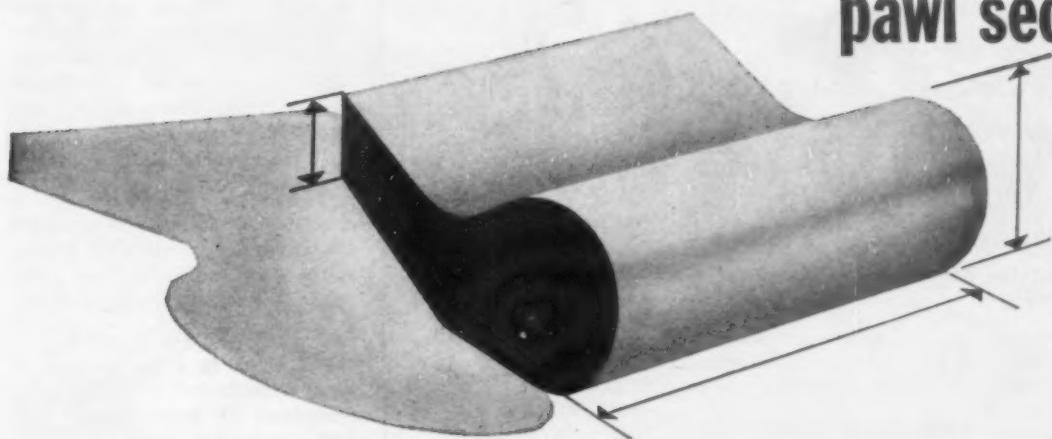
Bernard Trock () has expanded his special digest service to include a metallurgical consultant service in Detroit, specializing in material, process and heat treat specifications and service failure analysis.

Frank L. LaQue () has been elected vice-president of the American Society for Testing Materials for a two-year term. Mr. LaQue is vice-president of the International Nickel Co. and has served as manager of its development and research division since 1954.

Garrett A. Busch () is now an assistant in research and development at the Cleveland Graphite Bronze Corp., Cleveland, working with powder metals.

52% saving

reported with J&L hot extruded cold drawn pawl section



Red area shows scrap loss before
conversion to extruded section

This pawl was previously milled from a $\frac{3}{4}'' \times 1\frac{1}{4}''$ hot rolled oil hardening tool steel. Conversion to a cold drawn extruded section cut cost from 45¢ to 22¢ per part.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 405, 3 Gateway Center, Pittsburgh 30, Pennsylvania.



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STEEL ... a great name in steel

MEETING DESIGN NEEDS



The camera crank hinge, door knob and key for this REVERE 16mm Turret Model Motion Picture Camera are made of NICKEL SILVER powder—for important reasons.

Working with an experienced fabricator,* Revere engineers found that by designing specifically for powder metallurgy, THREE cost-saving advantages could be gained:

.. LOWER MATERIALS COSTS.

The nickel silver sinterings are less expensive than comparable parts produced from extruded stainless steel, the usual material used for similar parts.

.. LOWER PRODUCTION COSTS.

Metal powder sinterings eliminate expensive machining of holes and counterbore operations.

.. LOWER FINISHING AND ASSEMBLY COSTS.

Secondary operations are reduced to a simple drilling of a connecting hole for joining the knob and key and take advantage of the ease with which nickel silver may be given a light satin finish.

* Chicago Powdered Metal Products Company

How Can BRASS AND NICKEL SILVER POWDER PARTS Meet Your Design Needs?



For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of your particular needs.

◀ SEND FOR YOUR COPY



Personals . . .

E. S. Waldbott has left his position as chief metallurgist and process engineer at Vard, Inc., Pasadena, Calif., to accept a position as senior metallurgist at Convair, a division of General Dynamics Corp., in Pasadena, Calif.

Tom Richardson after five and one-half years as general engineer with the U.S. Army in Japan, working on joint U.S. Forces procurement (inspection, quality control and production), has moved into the design field at the new Naval Air Station at Cubi Point, Bataan, Philippines. He is now electrical engineer in charge of electrical work, plans and installations at this new air base.

William H. Miller has accepted the position of metallurgical trainee at the Corpus Christi, Tex., plant of the American Smelting & Refining Co.

J. R. Small is now engaged in metal control work for the Stanley Foundries of Huntington Park, Calif., following eight years as supervising metallurgist with the U.S. Naval Ordnance Test Station in China Lake, Calif.

A. H. Greisser has been promoted to superintendent of production for Portland General Electric Co., in charge of operation and maintenance of the company's hydro and steam electric generating plants.

Dean D. Lawthers formerly engaged in work on refractory metals with Westinghouse Electric Corp.'s research laboratories is now working on refractory metals at Universal Cyclops Steel Corp., Pittsburgh, in the company's pilot plant.

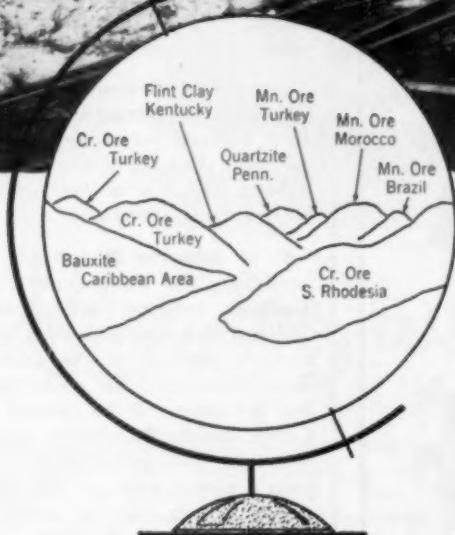
Chester S. Pondo has joined the Custom Tube and Spring Co., Sierre Madre, Calif., as chief metallurgist and vice-president. Before accepting this new position, Mr. Pondo was chief metallurgist and materials engineer for the Wiancko Engineering Co., Pasadena, Calif.

D. F. Sawtelle has joined Exomet, Inc., as a sales engineer. Prior to this new appointment, Mr. Sawtelle was chief metallurgist for the iron and steel foundries of Malleable Iron Fittings Co.

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Storage of ores at Beverly, Ohio, plant.



From the finest deposits throughout the world come ores—after painstaking sampling and testing at mines and docks—for Globe Ferroalloys.

Thus . . . quality starts at the source, and quality control is strictly maintained throughout the production of Globe Ferroalloys. The result—dense, clean ferroalloys of maximum physical and chemical consistency with a minimum of residual elements.



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LOW-CARBON FERROCHROME SILICONS • SILICOMANGANESE

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CHAMPION

Here's How

Upset Forgings

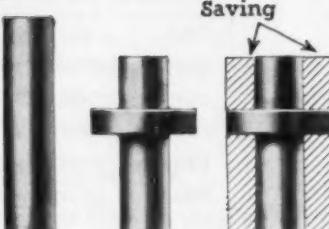
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Upset Forgings
Bulletin.

THE CHAMPION
RIVET COMPANY

CLEVELAND 5, OHIO

EAST CHICAGO, INDIANA

Personals . . .

Richard W. Holmes has become sales manager of the eastern division, north, of E. F. Houghton & Co., with headquarters in Worcester, Mass. Mr. Holmes moves to his new post from Detroit, where he was on the Houghton sales staff. He joined the company in 1950, following metallurgical work for Chrysler Corp., Detroit and J. E. Bullock Corp.

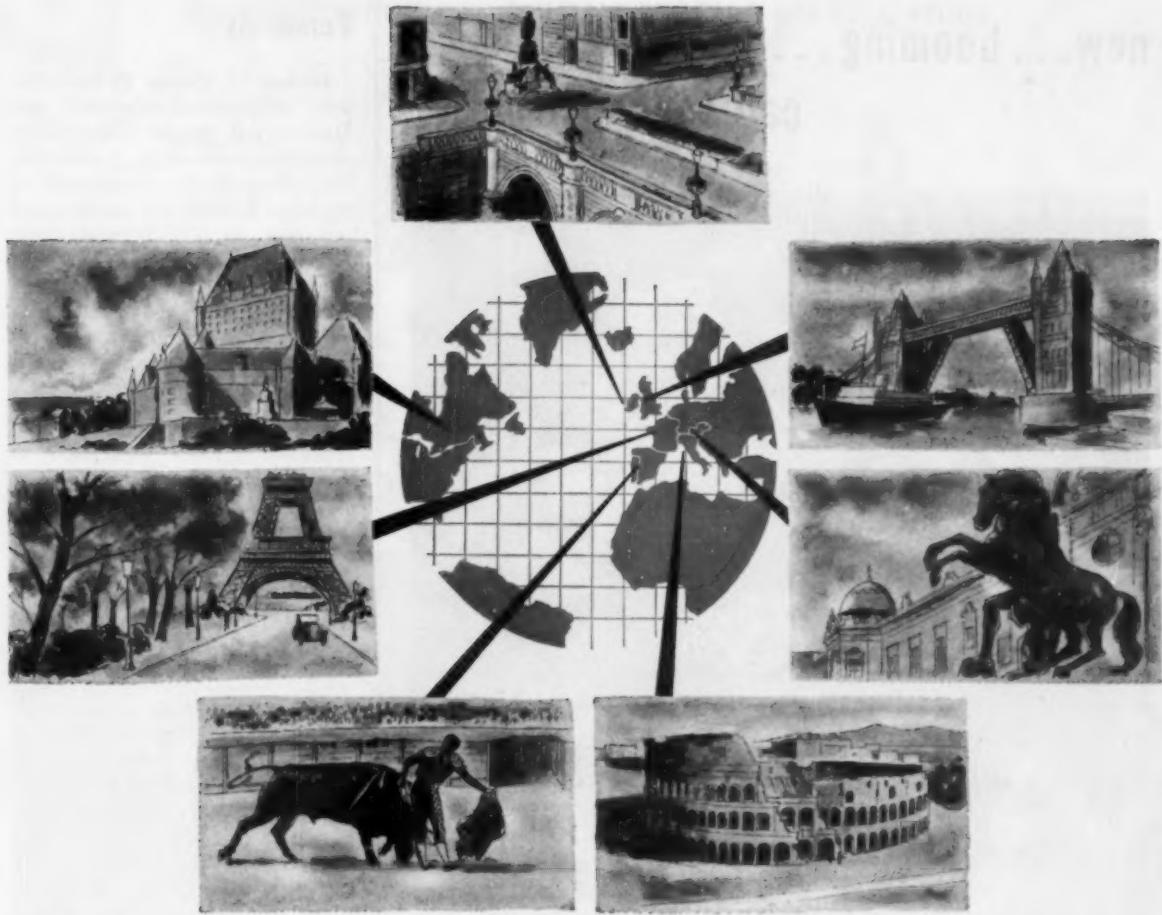
Edward Murway recently was appointed practiceman in the galvanizing department of Inland Steel Co., East Chicago, Ind.

William R. Martin and Ronald S. Mulhauser have joined the staff of the metallurgy department of Goodyear Atomic Corp., Portsmouth, Ohio. Both Mr. Martin and Mr. Mulhauser are recent college graduates, the former receiving his degree from the University of Cincinnati, the latter from Carnegie Institute of Technology.

Henry Otto Steinmetz is now engaged in engineering and development work on nuclear materials at the Bettis plant of the atomic power research laboratory of Westinghouse Electric Corp., Pittsburgh.

C. M. Schwitter , formerly supervisor of Far Eastern and Latin American technical developments, has been chosen to head the market research activities of the International Nickel Co., Inc., New York. Mr. Schwitter will be assisted by George Hoobler , formerly a member of the steel section of the company's nickel sales department. Joining Inco in 1930 as a research metallurgist, Mr. Schwitter was placed in charge of Far Eastern technical developments for the company and in 1956 his duties were expanded to embrace Latin American technical development. Mr. Hoobler joined the company in 1947, at the Bayonne, N.J., works, later serving in the Pittsburgh technical field section and more recently in New York as a member of the nickel sales department.

R. H. Robinson has been transferred from the Detroit office of the General Alloys Co. to the Buffalo office of the company as sales manager of the western New York area.



Here, too, we make Nichrome*

Perhaps you didn't know that the world-famous alloy Nichrome is produced not only in The United States, but also in 6 Driver-Harris plants in England, Ireland, France, Italy, Austria, Spain, and in Canada by The B. Greening Wire Company. Also, Nichrome is a registered trade-mark in 55 nations.

At first, fifty-odd years ago, we manufactured electrical resistance alloys for furnace elements and domestic

heating appliances only. Today we produce 132 different high nickel alloys in many different forms and in hundreds of sizes, for almost every kind of domestic and industrial application—of which Nichrome is the most illustrious.

Whenever you buy Nichrome, you are assured of the unsurpassed and unvarying quality which has made Nichrome the supreme world standard for electrical-resistance and heat-

resistant alloys. This uniformly high quality, which we jealously guard as our most priceless possession, results from the technical excellence, the productive skill, and the quality controls the Driver-Harris craftsmen have gained in over 50 years of experience—and which are maintained with equal rigor in all Driver-Harris plants here and abroad. The result is a continuous benefit to the entire electrical, electronic, and heat-treating industries.

*T.M. Reg. U. S. Pat. Off.



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MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

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Lower cost . . . better mechanical properties . . . and improved appearance are giving tremendous impetus to the new high-manganese stainless steels. Best of all, for those who have been working in the old high-nickel alloys, the new 200 Series requires no change in production operations, and possibly effects some savings.

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Personals . . .

Herbert M. Frazier heads the new International Chemical and Metallurgical Supply Corp. offices recently opened in Ft. Lauderdale, Fla., to supply the requirements of the metal finishing and metallurgical industries in Florida and Latin America. Mr. Frazier is president of the company while Wendell P. Barrows, , formerly affiliated with the National Bureau of Standards and the Naval Gun Factory, has been named secretary.

Donald A. Toland has been appointed a junior technologist in the vitreous enameling section of U. S. Steel Corp.'s Applied Research Laboratory, Monroeville, Pa.

Herbert A. Ball was recently named quality control manager of the Nuclear Fuel Div. of Olin Mathieson Chemical Corp., New Haven, Conn.

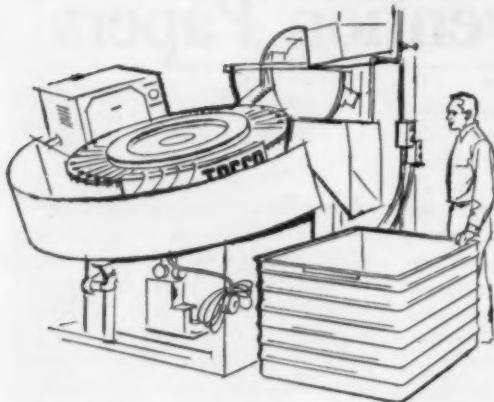
K. P. Campbell , works metallurgist for the Sheffield Div. of Armco Steel Corp. in Houston, Tex., has been promoted to general superintendent of operations, in charge of all phases of production. His former position will be filled by G. W. Brooks , process metallurgist. At the same time, several appointments were announced at the Kansas City Works of the Sheffield Div. J. N. Goldsmith was named assistant to the works manager and J. A. Walker was promoted to supervising metallurgist.

Lester A. Shea has been appointed eastern division manager of the Lindberg Industrial Corp., Chicago, with headquarters in Fair Lawn, N.J. Mr. Shea has been affiliated with the Lindberg organization for over 20 years, joining Lindberg Engineering Co. in 1937 and transferring to Lindberg Industrial Corp. in 1954.

V. K. Entrekin has left his position with Applied Research Laboratories in Miami, Fla. to take a post in the manufacturing and development division of Convair, a division of General Dynamics Corp., San Diego, Calif.

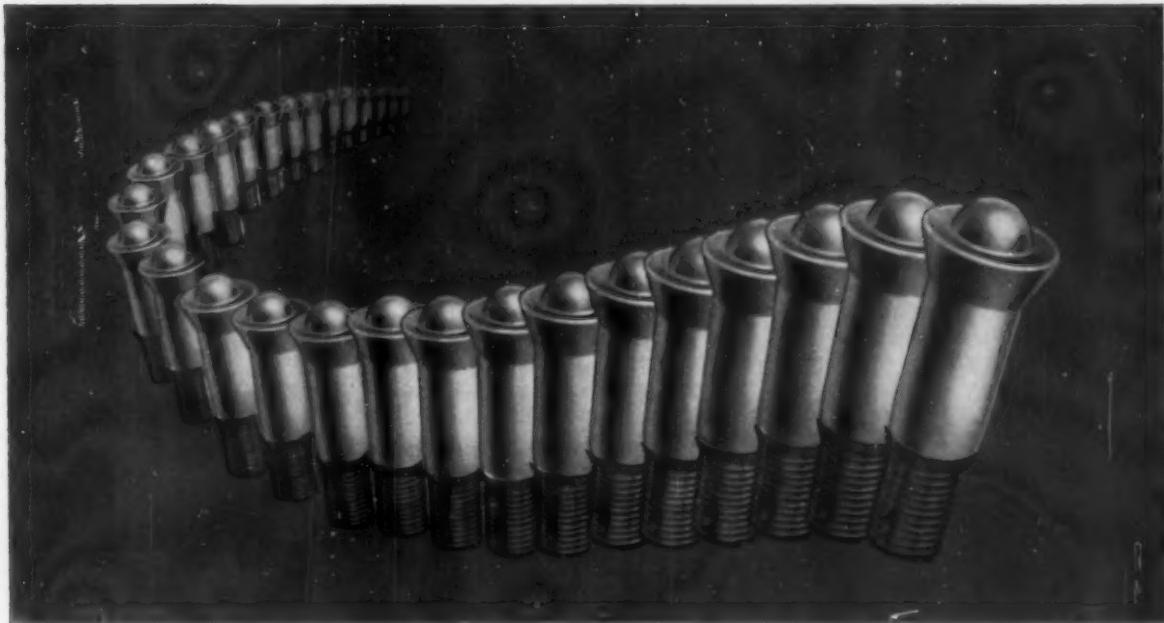
Robert H. Miller is currently superintendent of nonferrous foundry for the Universal Foundry Co., Oshkosh, Wis.

THOMPSON PRODUCTS ANNEALS THREADS ON BALL STUDS



ONE A SECOND!

with TOCCO Induction Heating*



Up Goes Production—When progressive engineers at Thompson's Michigan Division switched from conventional gas annealing to fully automatic TOCCO for annealing threads on automotive ball studs, production jumped from 2128 to 3226 parts per hour—an increase of over 50%.

Localized TOCCO heating draws threads from 60 to 30 Rockwell C, using 50 kw at a frequency of 10,000 cycles per second.

Down Go Costs—While production zoomed, costs dropped sharply with TOCCO annealing—a reduction of 34% in direct labor costs alone. With an average monthly output of 350,000 of these parts, Thompson saves thousands of dollars per year with TOCCO. If you heat metal parts for annealing, forging, brazing or hardening, investigate how TOCCO can up your production and lower your costs.



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Digests of Convention Papers

Influence of Nickel on Corrosion of Chromium Steels

Digest of "Influence of Nickel on Intergranular Corrosion of 18% Chromium Steels", by J. R. Upp, F. H. Beck and M. G. Fontana,  Preprint No. 51, 1957.

TYPES 304 and 430 steels can be made relatively immune to intergranular attack or made susceptible (sensitized) through selected heat treatments. Of interest is the fact that one heat treatment makes a steel immune and the other makes it susceptible. The question arises — at which nickel content does the switch occur?

One theory which explains the intergranular attack on Type 304 heat treated between 900 and 1400° F. is based on chromium impoverishment — lowering the chromium content adjacent to Cr_{23}C_6 precipitates results in less corrosion resistance in the adjacent areas. This may be avoided by treating at 2000° F. and water quenching to prevent carbide precipitation or by adding cobalt or titanium — both strong carbide formers — to the original melt to reduce the available carbon.

With Type 430 steel intergranular corrosion occurs in samples which have been cooled rapidly from 1700° F., but this attack may be prevented by short-time heating at 1450° F. Interesting facts about this attack are:

1. Martensite corrodes more than ferrite.
2. A precipitate of iron carbide can cause corrosion, although heat treating can cause the carbide to revert to a Cr_{23}C_6 which resists corrosion.
3. Titanium will not prevent intergranular corrosion by carbon removal, with attack still occurring when the carbon is only 0.005%.
4. Attack may be in stressed regions in the grain boundary caused

by carbides or nitrides formed on quenching, but this stressed region may be removed by treating at 1450° F.

To investigate intergranular attack, 12 alloys of 18% chromium stainless steels were prepared with nickel contents from 0 to 8.3%. After melting, the alloys were cast into round bars and rolled at 2000° F. into strips which were air cooled. These specimens were given various heat treatments and tested for corrosion resistance in a 240-hr. Huey corrosion test using boiling 65% HNO_3 . Data are reported in mils penetration per year. No photomicrographs are given. Metallographic studies on each specimen showed evidence of intergranular corrosion. The only effective heat treatments found were water quenching and furnace cooling from 1400 or from 2000° F. These heat treatments were either sensitizing or immunizing depending on the steel in question.

A sharp change in corrosion rates was found between 2.5 and 3.0% Ni content — specimens furnace cooled from 2000° F. showed extreme attack. In the low-nickel alloys the corrosion mechanism is one that would be exhibited by ferritic steels, whereas for nickel contents above 3% the austenitic-type mechanism dominates. This was verified from microstructures of the various alloys. The low-nickel alloys at 2000° F. showed a structure predominantly ferritic with 10 to 40% martensite, while at 1400° F. the structure consisted of masses of dark carbide in an all-ferritic matrix. The Fe-Cr system should not have martensite present, but with carbon the two-phase region of the gamma loop is moved to the right. Up to 5% Ni, alloys at 2000° F. showed more martensite and less ferrite, while at 1400° F. the structures were tempered martensite with ferrite stringers. At 2000° F. the 5 to 7% Ni alloys were just in the austenite field, and at 1400° F. the specimen exhibited severe grain-boundary corrosion.

One unusual fact noted was that

all specimens water quenched from 1400° F. showed no intergranular attack, although the structures were different. Prior heat treatments were found to have little influence on the results of the heat treatments given to the alloys before testing. Comparison tests between commercial and laboratory Type 304 and 430 steels were good, with the commercial alloys being attacked slightly more.

The authors believe that 18% Cr steels containing from 0 to 2.5% Ni can be properly heat treated — where intergranular corrosion is concerned — as ferritic steels, and those containing more than 3% Ni fall into the category of austenitic steels and should be heat treated accordingly.

D. L. McELROY

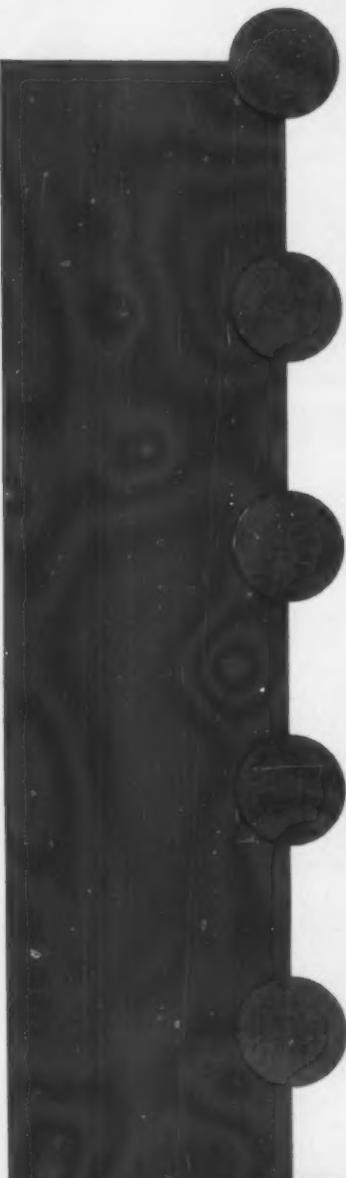
Effect of Manganese on Curie Temperature of Cementite

Digest of "Effect of Manganese on the Curie Point of Cementite", by Earl C. Roberts,  Preprint No. 11, 1957.

A NUMBER of alloying elements — particularly carbide formers — are known to replace iron in the cementite lattice. The alloying of cementite with manganese in steels and cast irons has been studied by several investigators using techniques of electrolytic extraction and chemical analysis. In the present work, this approach has been combined with determination of the Curie temperature of the cementite in a systematic examination of the change in manganese content of the cementite as a function of the manganese and carbon percentages in the steel.

Three series of steels of different carbon contents were used. In each series the manganese level was relatively constant (roughly, 0.25, 0.50, and 0.90%) and all were especially

60 CYCLE INDUCTION MELTING



A famous metallurgist once wrote: "50% of all rejects can be traced to faulty melting and pouring." When molten metal is overheated, important alloy ingredients are lost by burning. Castings or billets may be porous from combustion gases absorbed by the molten metal. Frequently, unwanted alloy ingredients are picked up from the containers used in melting. If the temperature of molten metal flowing into a mold strays from the optimum, defective castings will result. In a quiet melt alloy ingredients may not dissolve properly, and the metal cast will not meet specifications. Finally, there is the problem of nonmetallics suspended in the melt which cause occlusions and other difficulties in the end product.

60 CYCLE INDUCTION MELTING, properly applied, is probably the biggest single step that can be taken to overcome these traditional melting problems. The method is unique in its combination of two factors: Heat is generated only in the molten metal, and the entire melt is stirred by electromagnetic pressure. Furthermore, high melting rates can be concentrated in a small space.—No part of the furnace is hotter than the metal. Combustion gases are absent and controlled atmospheres can be used. The container is constructed of refractories inert to the molten metal. Temperature control of unprecedented precision is inherent in the method. Electromagnetic stirring assures complete dissolving of all ingredients and a uniform alloy. Suspended nonmetallics are deposited in the electromagnetic pressure area.

These are basic reasons why 60 CYCLE INDUCTION MELTING has had such a spectacular growth in the postwar period. Modern plants require high production rates with controlled quality, yet can assign only a minimum of skilled labor to each operation. 60 CYCLE INDUCTION MELTING minimizes hard labor in melting. It enables process control to substantially decrease the effect of human error. Cost reductions are reflected throughout each step of fabrication of a casting or billet to its end use.

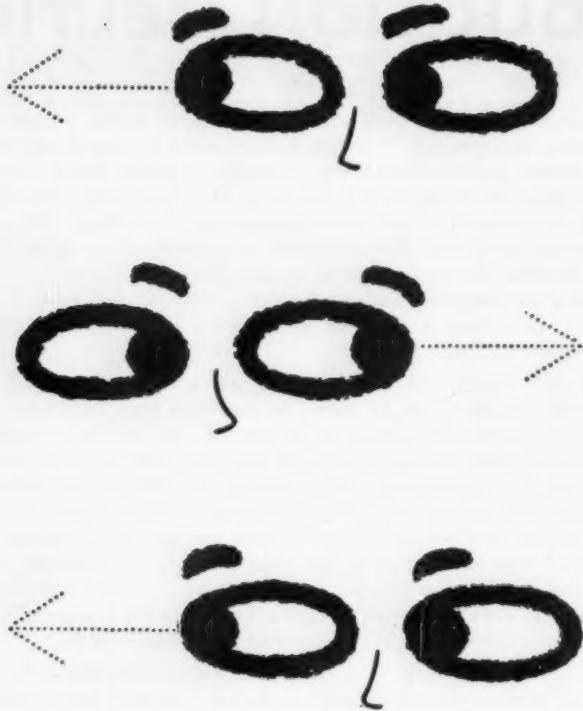
60 CYCLE INDUCTION MELTING, firmly established for thirty years as the predominant production method for melting brass, has recently been applied on a much larger scale. In the last ten years, as new furnace designs became available, the method has been rapidly adopted by many progressive companies in the fields of aluminum die casting, aluminum extrusion, aluminum wire, aluminum coating, leaded copper alloy casting, zinc die casting, and galvanizing of strip in the steel mills. Well over one thousand 60 CYCLE INDUCTION MELTING furnaces are now operating in these new fields.

Our 60 CYCLE INDUCTION MELTING furnace takes many different forms to meet the needs of all these industries. Unit production rates now range from 150 pounds to 40 tons per hour. We specialize in the development, design, and manufacture of standard and custom-built furnaces to meet each requirement. If there is a production melting problem in your operation which may benefit from a basic change in method, we should be glad to discuss the possibilities with you.



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Alternating stresses bear watching!

Back and forth... up and down... in and out... if those stresses keep changing, the life of a metal part is a hard one... and often a short one. Stress reversals can cause "fatigue" failure at stresses far below the expected strength of the metal.

One of the outstanding properties of phosphor bronze is its high resistance to fatigue failure. It is widely used for electrical switch parts, relay contact springs, bellows, rotating shafts and other moving or vibrating parts.

For detailed information on phosphor bronze, write to

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RIVERSIDE-ALLOY METAL DIVISION

Curie Temperature . . .

prepared to have a minimum residual alloy content. A high-purity iron-carbon alloy of approximately 1.00% carbon was included in the study to establish a reference Curie temperature for manganese-free cementite. To avoid difficulty with variations in Curie temperature with very fine cementite or as a result of cold working, all specimens were annealed in vacuum for 100 hr. at 1200° F. after machining and cleaning. After magnetic measurements were made to determine the cementite Curie temperature (averaging results obtained by slowly heating and cooling to above the transition temperature), the carbides were extracted electrolytically from the specimen and analyzed for iron and manganese.

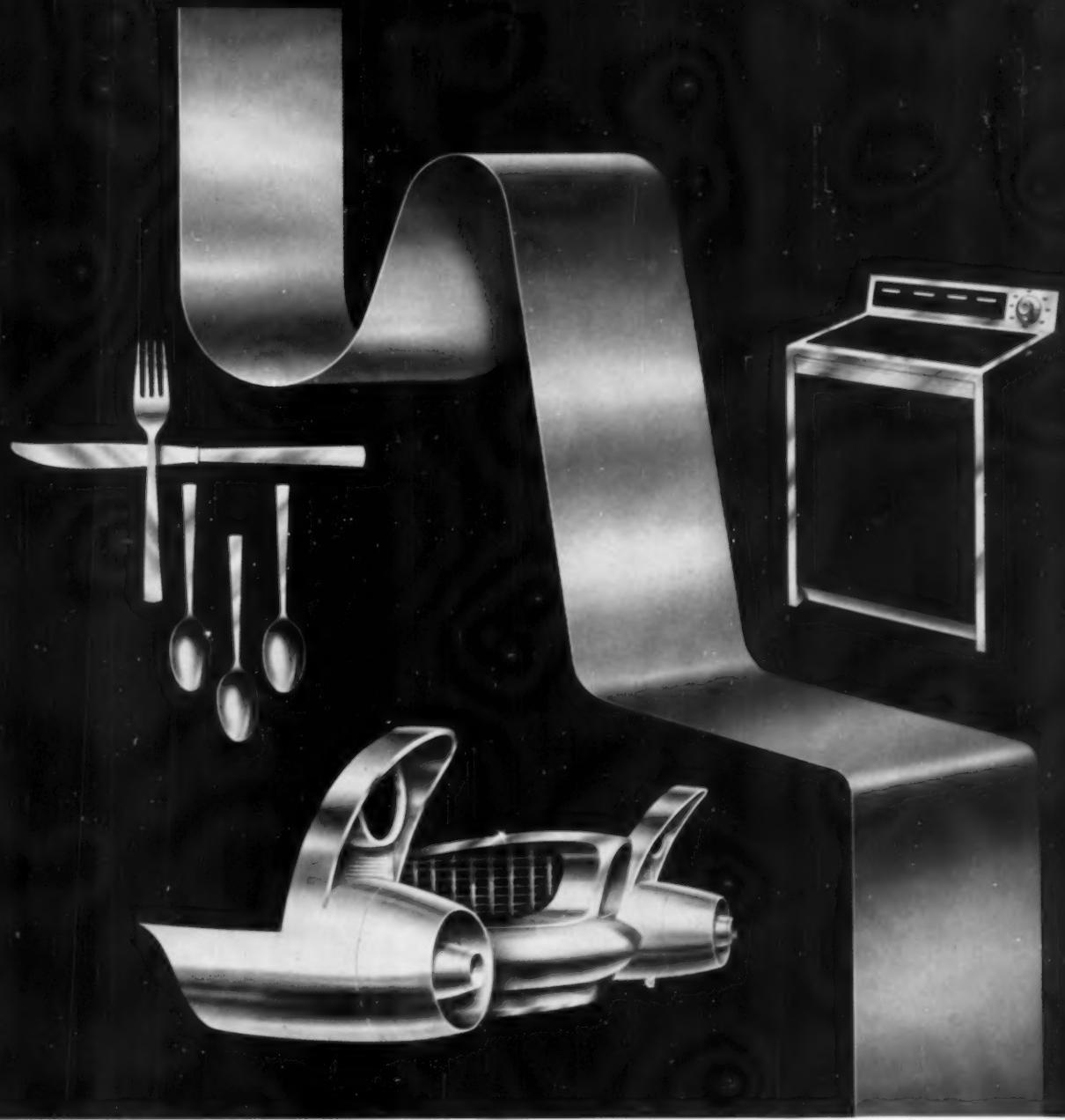
The results show a linear decrease in the Curie temperature of the cementite with increase in the manganese content of the carbide. The relationship can be expressed by the equation:

Curie temperature (°F.) =
406 - 39.3 (% Mn in cementite)
This simplified expression gives an approximate calculation if either of the two variables is known.

Of some practical importance is the relationship between the percentages of manganese in the steel and manganese in the cementite. This has previously been thought to be a straight line, but the present investigation indicates a curvilinear relationship. A very marked dependence on the percent carbon in the steel was also observed. Thus, the relationship between the manganese content of cementite and the manganese content of the steel can be expressed as a parabolic equation in which the carbon content of the steel must be considered. The empirical equation derived for this relationship was tested against the experimental data with an overall error of only about 6% for the range of conditions studied.

The author points out that in the two specimens for which the empirical equation failed, the silicon content either was low or was undetermined. This is given as indication of the importance of silicon on the distribution of manganese between carbide and ferrite in annealed steels.

G. H. ENZIAN



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CRUCIBLE

first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

1000 KW dual frequency induction heater for steel forging.



James McLaughlin, Sales Manager, Low Frequency; Pete Hassell, Sales Manager, High Frequency; John Logan, President; Bruce McArthur, Vice President; Ted Kennedy, Chief Engineer.

the Brass does much more than "TAKE A LOOK"

The Magnethermic brass has a personal interest in this heater.

They have combined their talents on the original design, the application engineering, and the fabrication. Little wonder that they take this close look in the final stages of production.

This procedure is standard—not the exception. All Magnethermic Heaters, large

or small, receive day-to-day supervision of the President, Vice President, Chief Engineer and other well-known authorities on induction heating.

Specialized attention to each order for induction heating equipment . . . high, low, or dual frequency can be applied only in a specialized company like Magnethermic where induction heating is the only business.

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Heating
Equipment
60 to 450,000
cycles

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New, tougher tool steel
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as much as 400° lower...
machines faster

THIS new tool steel—Graph-Air®—air-hardens at temperatures as much as 400° lower than other air-hardening tool steels. Temperature as low as 1450° F. is sufficient. This means simpler heat treat control, less distortion.

Because of its graphitic structure, Graph-Air machines faster. And there's less decarburization than with other air-hardening steels. Longer life, because the uniform, diamond-hard carbides in its structure help Graph-Air outwear other tool steels. And you get longer-lasting accuracy, because of Graph-Air's built-in stability. Graph-

Air is fully as stable as other Timken Company graphitic tool steels, the most stable ever made.

Graph-Air's uniformity of hardening plus minimum distortion make possible more intricate sections. You'll find it a better-than-ever answer for blanking dies and other steel parts that must withstand hard abuse.

For your jobs requiring a high quality, lowest-temperature air-hardening tool steel, specify Graph-Air. Available in solid and hollow bar sizes. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN STEEL

Fine
Alloy

TRADE MARK REG. U. S. PAT. OFF.

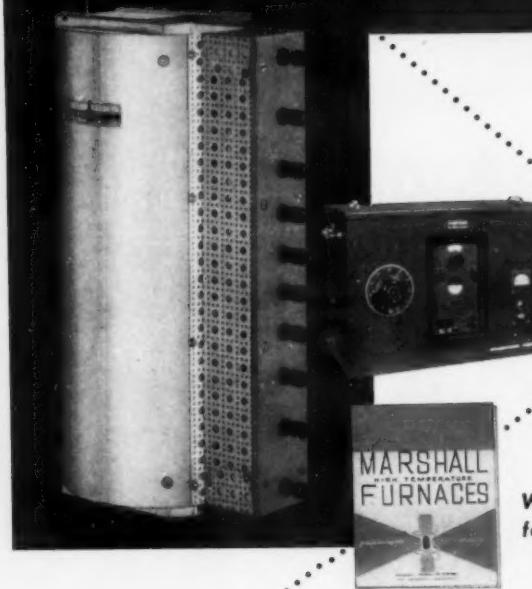
SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

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Limits of Solubility of Carbon in Thorium

Digest of "Solubility of Carbon in Thorium", by Robert Mickelson and David Peterson, Preprint No. 7, 1957.

PRIOR STUDIES of thorium alloys have indicated that carbon is the most effective addition for increasing the hardness and strength without seriously reducing ductility. The stable carbide phase in equilibrium with thorium at room temperature is thorium monocarbide, and it is completely soluble in the liquid and solid states at high temperatures. At intermediate temperatures, the limits of carbon solubility have been studied only briefly in early work by Saller, who found discrepancies between results obtained by the X-ray and metallographic methods. The present study was undertaken to provide additional fundamental data.

Carbon solubility was determined by X-ray measurements of the lattice parameter of slowly cooled and quenched specimens of thorium-carbon alloys. A North American Phillips back-reflection camera (12 cm. diameter) was used. The results of the X-ray tests were verified by metallographic examination and hardness tests.

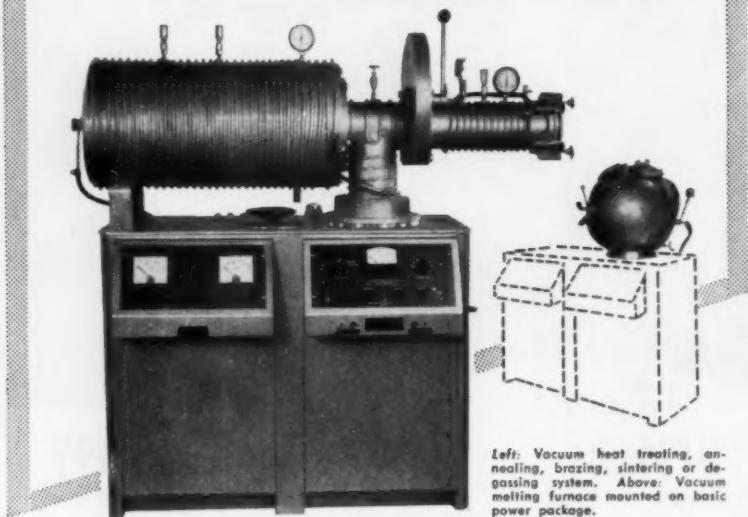
The thorium-carbon alloys were prepared by arc melting low-carbon, bomb-reduced thorium sponge with high-purity graphite in a purified helium atmosphere. Each sample was turned and melted three times to insure homogeneity. Carbon contents of the 17 alloys analyzed between 0.025 and 1.23% by weight. The average nitrogen content was 0.032%, and values of individual alloys were generally within 50% of the average value. Spectrographic analyses of the sponge and several of the alloys showed only small amounts of the several metallic impurities normally found in thorium metal. Thorium oxide, not determined analytically, was estimated metallographically to be present in amounts ranging between 1 and 2%.

Specimens containing less than 0.1% C were prepared by hot rolling into 1/16-in. thick sheet. The more brittle, higher-carbon specimens could not be rolled, and were cut into blocks 1/16 in. thick and 1/4 in. wide.

The room-temperature solubility

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Carbon in Thorium . . .

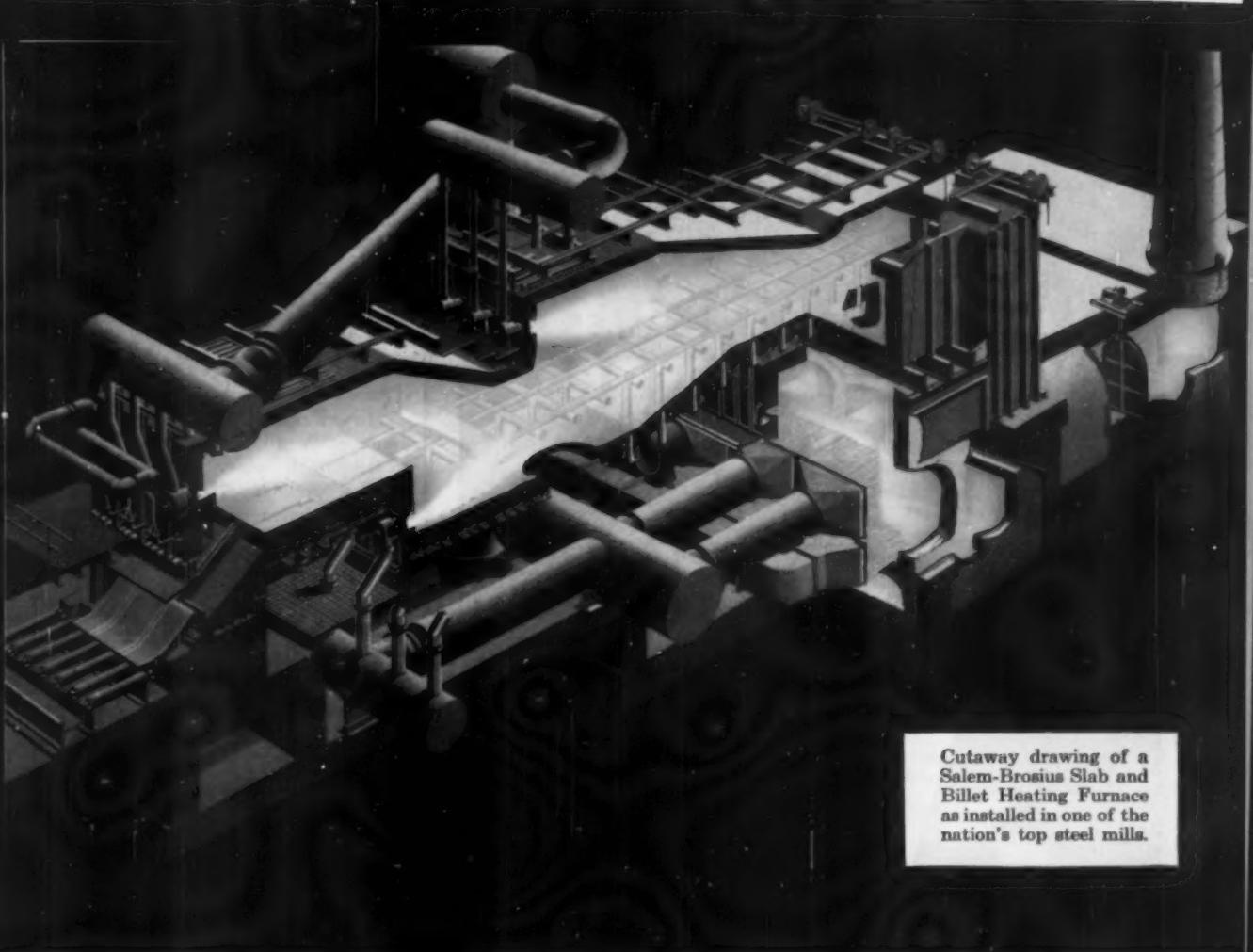
limit was determined on specimens held at 900° C. (1650° F.) for 6 hr. and cooled to room temperature over a 5-day period. During heat treatment, specimens were contained in quartz tubes evacuated to less than 0.02 μ . Solubility limits at higher temperatures were determined on specimens which were heated for $\frac{1}{2}$ hr. or more in a vacuum of 0.4 μ or less. Specimens were quenched by allowing them to fall directly into a bath of Wood's metal at 80 to 100° C. (175 to 212° F.).

Prior to X-ray examination, specimens were vigorously pickled in dilute nitric-hydrofluoric acid to remove surface metal possibly contaminated during heat treatment. Most of the X-ray photographs showed sharply defined lines of thorium oxide, and these lines were used as internal standards to eliminate systematic errors in determination of the lattice constants of the metal. Samples containing in excess of about 0.5% C were very coarse-grained and gave spotty patterns so that a large random error was present with such specimens.

The lattice parameter of the different specimens increased with carbon content and leveled off at values taken to be the limit of carbon solubility at the different temperatures. The data indicate that thorium will dissolve 0.3% C at room temperature, 0.43% carbon at 800° C. (1470° F.), 0.57% carbon at 1018° C. (1680° F.), and 0.91% carbon at 1215° C. (2220° F.). These results were confirmed by metallographic examination. Thorium carbide was identified as small square particles, easily differentiated from the larger and darker thorium oxide particles.

An anomalous effect was observed in samples containing less than 0.35% C in that the lattice constant and hardness of quenched specimens were greater than those of slowly cooled specimens. This behavior was attributed to the presence of nitrogen as an impurity in amounts greater than the solid solubility at room temperature. Additional nitride retained in solid solution by quenching from elevated temperatures probably caused the increased lattice constants and greater hardnesses that were observed.

R. E. ADAMS



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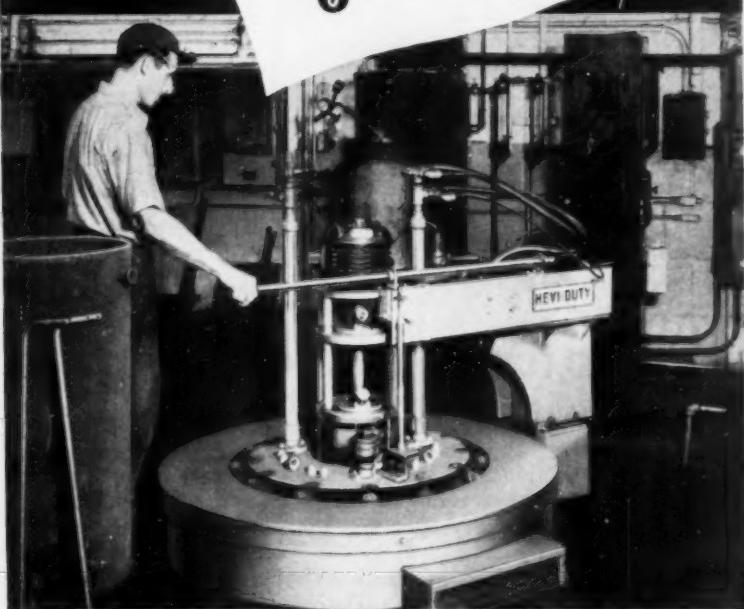
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Effects of Cycling on Rate of Growth of Rolled Uranium

Digest of "Effects of Cycling Variables Upon Growth Rate of 300° C. Rolled Uranium", by R. M. Mayfield, Preprint No. 37, 1957.

BECAUSE of its high degree of preferred orientation when in rod form, uranium can undergo permanent growth when subjected to thermal cycling. The amount of growth is determined by the texture of the material and the cycling conditions. An accurate knowledge of the effects of variations in the latter is required before an adequate theory of the effect can be formulated. The present work represents a comprehensive study of the effect of heating and cooling rates, temperature limits and other cycling conditions on the rate of growth.

The majority of the work was carried out in a vertical tube cycling apparatus having two chambers held at different temperatures. Specimens of 99.9 + uranium, rolled at 300° C. (570° F.) and annealed at 600° C. (1110° F.), were transferred from one furnace tube to the other by raising in a tube filled with NaK extending between the two.

The growth rate for different conditions was evaluated by comparing the growth coefficient G_t . This coefficient is the true extension per cycle per unit length and is compared to the "instantaneous" length rather than the original length. The growth rate coefficient used was generally that after 100 cycles. The growth rate approached very low values when the upper temperature was 350° C. (660° F.) and below, so that most of the work was confined to temperatures above 350° C. (660° F.). The maximum growth rate occurred with slow heating and fast cooling and with time at temperature of at least 30 min. Reversal of these conditions led to the minimum amount of growth. None of the conditions studied led to zero growth even when very slow rates of heating and cooling were used. This fact tends to discount any theory relying on thermal gradients as a cause of growth.

With increasing upper temperature of the cycle above 350° C.

(660° F.), the growth rate increases sharply. Likewise, a greater temperature range also means greater growth rates. It should be noted, however, that other workers have observed growth when the temperature range was $\pm 2^\circ$ C. There appears to remain some conflict over the exact temperature dependence of the growth rate. This difficulty is not readily resolved since the process is not isothermal and it is not clear at what stage in the cycle the growth takes place. It is doubtful that the activation energies calculated from the present data refer to any single process. Any model for the growth mechanism must, however, account for the observed effects of the cycling variables.

RAY W. GUARD

Uranium-Titanium Alloys for Reactors

Digest of "Some Properties of Uranium-Low Titanium Alloys", by Daniel J. Murphy, Preprint No. 40, 1957.

EXTENSIVE USE of natural and enriched uranium in solid form is currently anticipated in several atomic reactors. Many difficulties are encountered, especially in water-cooled and moderated reactors, because of the corrosiveness of water on uranium.

Earlier work in uranium alloys suggested the possibility that by the addition of small amounts of titanium, a product with greater strength and corrosion resistance might be obtained.

Five cast alloys were prepared, ranging from 0.09 to 1.40% Ti by weight. These were subsequently evaluated for tensile, yield, impact and corrosion resistance in a variety of heat treated conditions. In general, increasing titanium contents increased the tensile and yield strengths as well as hardness, while elongation and impact values decreased. The same trend was established on all of the heat treated specimens, with certain exceptions: Elongation increased and impact strength decreased for all compositions heat treated, except those that were water quenched from 725° C. (1335° F.). In these samples, a distinct plateau for all compositions up to 1% Ti was exhibited, with values

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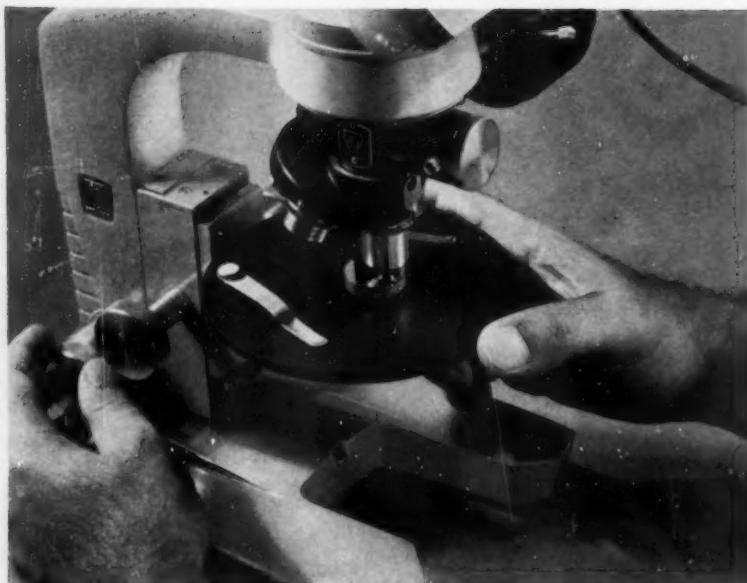
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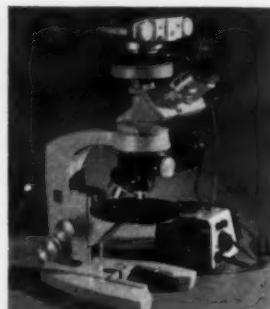
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U-Ti Alloys . . .

in the range of 20% elongation and 20 ft-lb. impact.

Increasing titanium content also increased resistance to water corrosion. As little as 0.1% Ti increased corrosion resistance ten-fold, and quenching from 800° C. (1470° F.) brought further improvement.

When a 3% Ti alloy was aged by holding 1 hr. at 500° C. (930° F.) hardness increased up to Vickers 600. Precipitation of U₂Ti is suggested as the mechanism.

The author concludes that beneficial mechanical effects result from additions of titanium in the range of 0.1 to 1.5%, that properties obtained depend strongly upon the thermal history and heat treatment, and that there is a finite possibility of achieving these beneficial results in massive pieces by the addition of third elements which would decrease transformation rates in the base metal. Comparative data, curves and photomicrographs are included in the presentation.

J. L. WYATT

Hydride Precipitation in Alpha Titanium

Digest of "The Mode of Hydride Precipitation in Alpha Titanium and Alpha Titanium Alloys", by Tien-Shih Liu and Morris A. Steinberg, *Preprint No. 34, 1957*.

THE DETRIMENTAL effects of hydrogen upon the mechanical properties of titanium have been common knowledge for some time, and considerable efforts have been spent to elucidate the mechanisms.

Anticipating that knowledge of the mode of hydride precipitation will provide a sounder basis for understanding the hydrogen embrittlement itself, Liu and Steinberg studied the hydride precipitation in alpha titanium and several alpha titanium alloys.

Samples were hydrogenated either in a modified Sivert's adsorption apparatus or in a continuous flow of purified hydrogen. Large hydride particles were formed if hydrogenation at 662 to 752° F. was followed by furnace cooling in hydrogen.

(Continued on p. 156)

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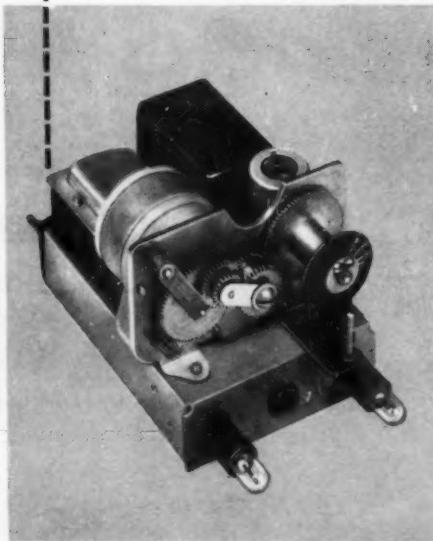


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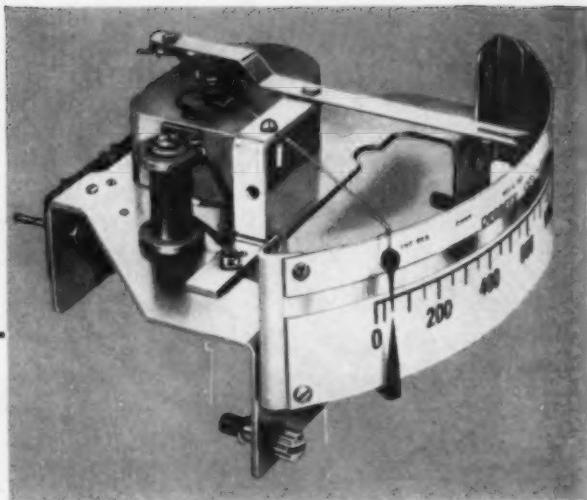
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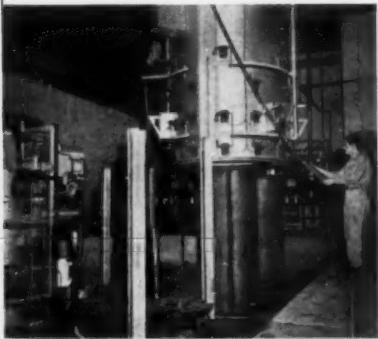
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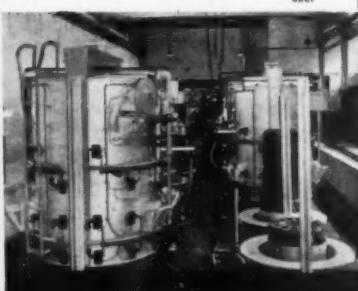
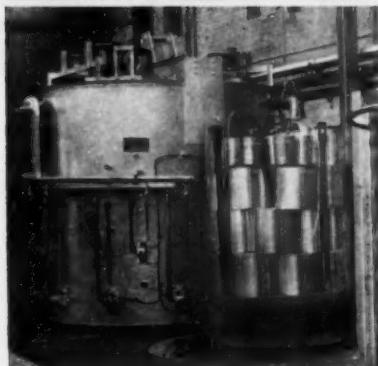
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Hydrogen in Titanium . . .

Because of the scattering powers of hydrogen and titanium, diffraction methods could not be used for determination of hydride orientation; instead, optical and metallographic methods were employed, using the two-surface method.

The shape of the precipitated hydride particles is basically the same in both the pure titanium and in the alloys, namely, thin needles. The following habit planes for precipitation were found:

Ti and Ti-2% V (1010) (1011)

Ti-10% Zr (1011) (1122)

Ti-3% Ta (1011) (1121) (1122)

Ti-3% Al (1011) (1121) (1012)

The following crystallographic relationships were postulated:

(1010) α Ti (101) TiH f.c.t.

[2120] α Ti [011] TiH f.c.t.

and

(1011) α Ti (101) TiH b.c.t.

[2120] α Ti [100] TiH b.c.t.

Two of the habit planes fall on two of the three possible slip planes for titanium at room temperature. The authors suggest that this could conceivably lead to a shortened nucleation period for the slip process. A shortening of this type does not affect the behavior in static tests, but could be noticeable in tests such as impact.

K. M. CARLSEN

Cause of Brittle Failure of Mild Steels

Digest of "The Initiation of Brittle Fracture in Mild Steel", by J. A. Hendrickson, D. S. Wood and D. S. Clark, Preprint No. 28, 1957.

THE RESULTS presented in this paper add to our knowledge of the cause of brittle failure of mild steels. Notched tensile specimens of annealed mild steel were subjected to constant rates of loading at different temperatures. The interrelation between temperature, loading rate and stress state beneath a notch, which governs the initiation of brittle fracture, was quantitatively determined.

Since a notched tensile specimen exhibits both elastic and plastic deformation prior to brittle fracture, an elastic-plastic stress analysis approach

(Continued on p. 160)

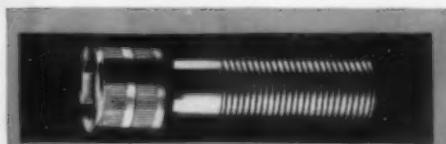
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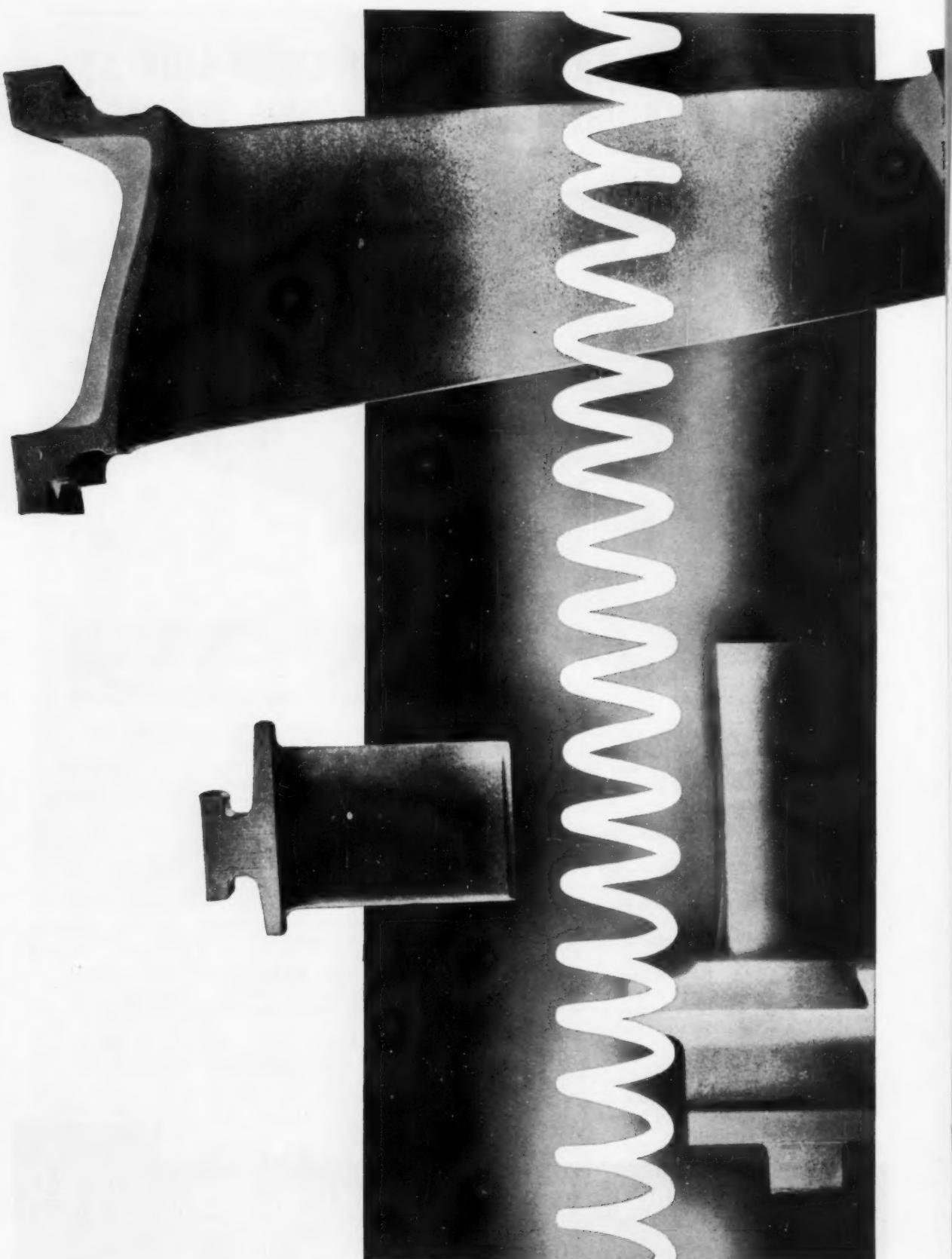
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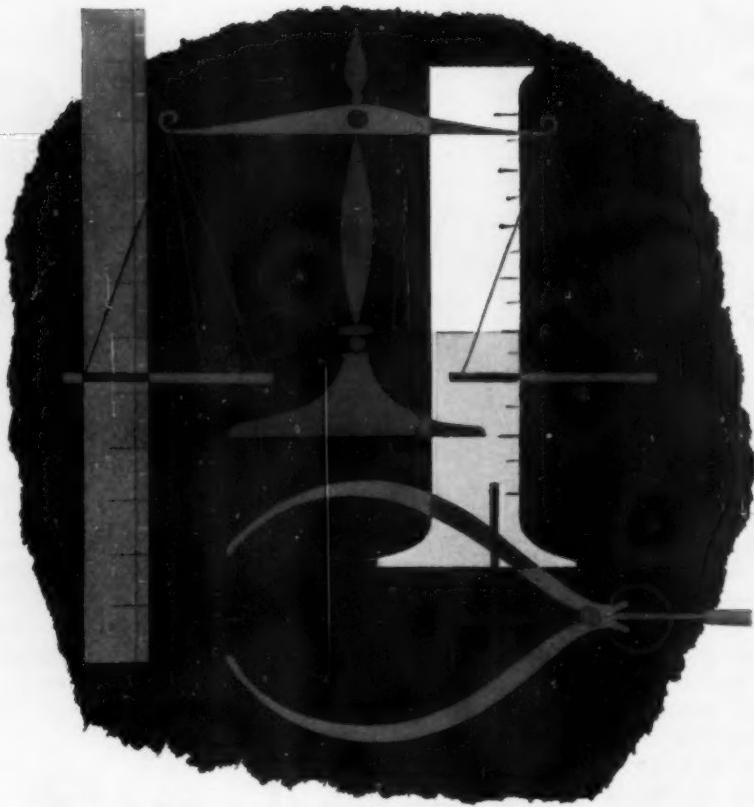
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Brittle Failure . . .

priate for the experimental results obtained in this investigation was developed. The necessary assumptions were:

1. The material was assumed to be homogeneous and isotropic in both the elastic and plastic regions.
2. Hook's law was assumed to apply at any point in the elastic region.
3. The material was assumed to be free of strain hardening.

4. Plastic deformation will occur when the maximum shear stress reaches a critical value.

5. The direction of the maximum shear stress was assumed always to lie in a constant fixed plane.

6. The displacements of the free (notch) surface will be small enough so the shape of the notch contour during plastic deformation need not be taken into account.

A 0.17% carbon steel in the form of $\frac{3}{8}$ -in. diameter bars was annealed and notched in a curvature which was a hyperboloid of revolution. The dimensions of the notches were determined by an optical comparator. The load was applied at desired constant rates, and determined as a function of time by a dynamometer and oscillograph record. Specimens were tested at temperatures of -25 , -110 and -200° F. The position of the elastic-plastic boundary was determined experimentally for several specimens at -110 and -200° F. by micro-hardness tests in the vicinity of the notch.

The results showed that the position of the elastic-plastic boundary at the base of the notch determined experimentally was in agreement with the position predicted by the stress analysis.

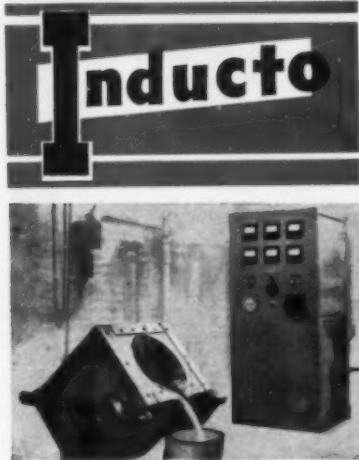
The true tensile stress at the position and at the instant of brittle fracture was determined from the experimental results by stress analysis. Brittle fracture was initiated in the steel studied at 210,000 psi. This value was independent of stress rate and temperature. Brittle fracture in the notched specimens depended on notch acuity, stress rate and temperature. The influence of stress rate and temperature on the initiation of brittle failure was found to be associated entirely with the dependence of the yield stress on temperature and stress rate.

D. J. CARNEY

Metal Progress

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SELECTOR SWITCHES . . . Can be mounted on lower front of control panel for maximum accessibility and minimum bus losses. You can change furnaces in a few seconds.

For details, write for our Bulletin 70.



LIST NO. 144 ON INFO-COUPON PAGE 170



SAVE SPACE WITH A SERIES 8055 COMBINATION MODEL

Two independent furnaces (hardening and drawing) in the same floor space one requires. Complete with independent controls. Hardening furnace available in both a 2000° and a 2300° F. range.

Drawing furnace has a maximum of 800° F.* Quench tank included with the exception of the largest standard model.

Model	H. 6"	W. 9"	L. 12"	2000° F.	2300° F.
				\$ 865.00	\$ 975.00
8055 B	9"	9"	18"	1325.00	1450.00
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*Also available up to 1250° F.

WRITE FOR FREE LITERATURE, SPECIFICATIONS and price list of Lucifer Furnaces in wide range of sizes—top loading and side loading types. Engineering advice without obligation. Write, wire or phone today.

LUCIFER FURNACES, INC.
NESHAMINY 7, PA.
Phone: Diamond 3-0411

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LOAD HEAT TREAT FURNACES

automatically



Meters... Conveys...

Elevates up to 5,000 lbs. per hour

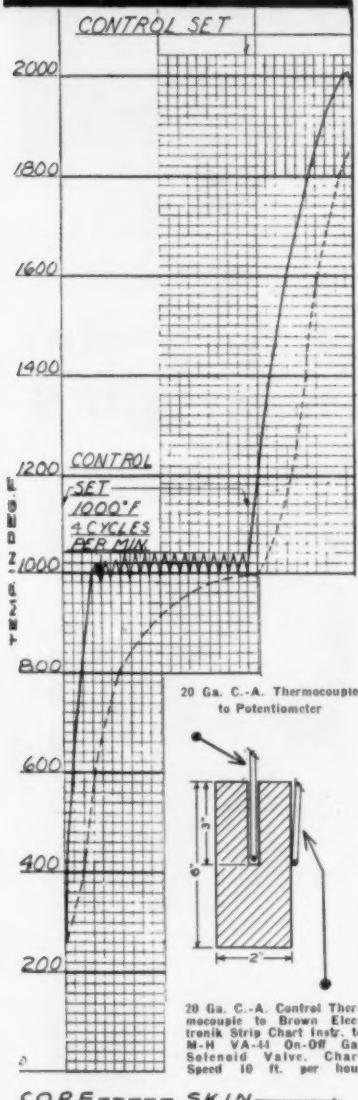
Some of the largest metal working plants in America have proven that Man-O-Steel Furnace Loaders give fewer rejects, lower labor costs and increased production. Write today for bulletin.

MICHIGAN
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Instantaneous Heat!

Firing Rate: 50,000 B.T.U. Per Sq. Ft.
Blower Air = 117 C.F.M.



INSPECT THIS PROVEN COMBUSTION SYSTEM

THE A. F. HOLDEN COMPANY

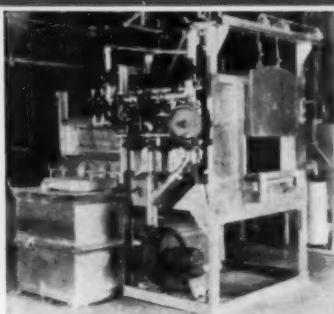
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DETROIT

MICHIGAN

LIST NO. 127 ON INFO-COUPON PAGE 170

KOZMA Radiant ALUMINUM DIE CASTING FURNACES



- Melt and hold in one compact unit
- Minimize metal loss
- Eliminate flame impingement and localized over-heating
- Melt faster, save fuel
- Offer increased ease of operation
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RADIANT ALUMINUM DIE CASTING FURNACES are available with either side or end dipout arrangements in 300 to 2,000 lb. melting capacities.

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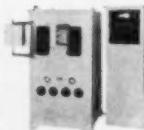
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ELECTRIC FURNACES custom designed or standard models at practical prices



Dyna-Bar High
Temperature Furnace



Dyna-Trol Furnace

- Temperature Range—Dynamal to 2300° F. Dynamax to 2850° F.
- Dynatrol models—from 890°
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- Pyrometer selector switch for zone temperature indication.
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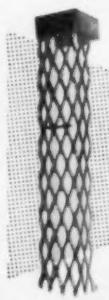
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CATALOG M-7

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FREE

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Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .

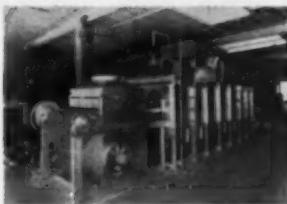


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INDUSTRIAL OILS, Inc.**

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SFE RECIRCULATING FURNACES



1000 lb. per hr. S.F.E. recirculating draw furnace, complete with cool down. For temperatures from 250 to 1250° F.

Write for complete information.

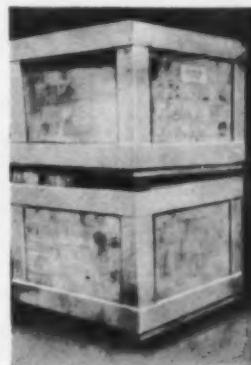
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WE PAY CASH FOR SURPLUS INDUSTRIAL FURNACES
AND RELATED APPARATUS

LIST NO. 160 ON INFO-COUPON PAGE 170

SURPLUS FURNACES FOR SALE

BOX TYPE

27x54x20	G.E.	50KW 2000°F	36x36x36	Despatch	Gas 1250°F
36x72x23	G.E.	72KW 2000°F	72x12x42	Lindberg	Gas 1250°F
48x84x24	American	100KW 1850°F	24x36x18	Lindberg	35KW 1250°F
30x36x18	Surface	Gas 1850°F	36x48x24	Lindberg	45KW 1250°F
54x96x24	Surface	Gas 1850°F	66x16x76	Lindberg	180KW 1250°F

PIT TYPE

25x36	Lindberg	66KW 1250°F	15x18	L&N Homo	30KW 1800°F
22x26	Lindberg	Gas 1250°F	20x36	L&N Homo	72KW 1800°F
48x72	Lindberg	Gas 1250°F	25x36	L&N Homo	85KW 1800°F
48x96	Surface	Gas 1250°F	20x48	L&N Homo	85KW 1800°F
48x96	Lee Wilson	Rad. Tube	24x48	Hevi Duty	100KW 1800°F

CONVEYOR TYPE RECIRCULATING

36x33'x12	Despatch	MshBit Gas 875°F	28"	G.E. 17'htg.	70°C. 320KW 2050°F
27x15'x12	R&S	MshBit Gas 1250°F	28"	G.E. 28'htg.	90°C. 497KW 2050°F
48x20'x12	Surface	PitBit Gas 1000°F	62"	G.E. 18'htg.	45°C. 655KW 1650°F

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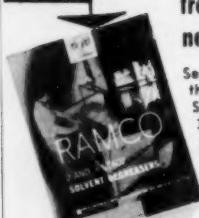
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Q A

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See how Ramco 2-
and 3-dip degreasers can
solve your metal
parts cleaning prob-
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ciently, economical-
ly! Send today!

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COLO., Denver 16—Fred E. Blair, Blair Engineering Co., 4100 Grape St., Phone Florida 5-7142.

CONN., Wethersfield—Richard D. Lindner, Metallurgical Products Co., 583 Wokott Hill Rd., Phone Jackson 9-6381.

IND., Indianapolis 1—William McAfee, 626 N. Delaunay St., Phone Fleetwood 7-1483.

MASS., Brookline 46—Harry J. DiCarlo, Metallurgical Products Co., 1199 Beacon St., Phone Longwood 6-8993.

MICH., Detroit 35—Carl H. Schmidt Co., 16405 W. Eight Mile Rd., Phone Broadway 3-8500.

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N. Y., Syracuse 2—J. R. Stewart Co., 532 University Blvd., Phone Harrison 2-9686.

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It Discusses

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Steel

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RUST
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OIL-KOTE—solvent type**SOL-U-KOTE**

—water emulsified types
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blackening and plating.

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Grade "C-W-25"**Non-flammable****Non-toxic**

**Aqueous Oily Film
Protects Ferrous Parts
for Long Periods
Indoor Storage**

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**HARD
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has practically
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Technic HG Gold provides all the attributes you have needed in hard bright gold. In particular, cyanide is less than 1/10 oz. per gallon . . . cost is less than 10¢ per troy oz. over regular 24 kt. gold. In addition —

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Jackson 1-4200

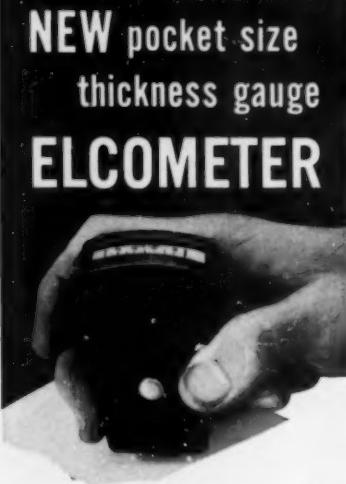
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with $\pm 5\% \pm .0001"$ Accuracy

ELCOMETER measures thickness of porcelain enamel, paints, platings, foils, glass, paper, plastics, and other non-magnetic coatings quickly and accurately. Gauges flat or curved surfaces and hard-to-get-at spots easily. Needle locking device assures correct reading every time. Complete with tough leather case containing inner pocket for test strips. Weighs only 6 oz. Completely self-contained. Retail price: \$68.00 F. O. B. Cleveland.

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Electrochemical etcher for faster, better, lower cost permanent metal markings!



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- Plating tanks any size or shape fabricated and rubber-lined to your specifications. A complete service from basic design to installation, also fabricated and rubber-lined pipe and fittings. Write Dept. "MP" for complete details.

Subsidiary of Automotive Rubber Co., Inc.
ARCO STEEL FABRICATORS • INC.
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DUCTILE CHROMIUM

This new ASM book contains a general review, a section on the production of chromium metal, discussion of ductile chromium metal, data on effect of gas on chromium metal, and a conclusion on high-chromium alloys.

From papers presented at the 1955 Metal Congress by 45 investigators.

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TENSILE TEST BAR
MPA STANDARD
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- Tensile Bars
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- Bushings
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Complete design facilities for dies or subpress units to press unusual shapes in lab presses.

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AND KNOOP
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STANDARD
HARDNESS TESTERS
for ROCKWELL
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BRINELL TESTS
also available.

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Inspection Demagnetizing or Sorting PROBLEMS?

SOLVED with

MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

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LIST NO. 51 ON INFO-COUPON PAGE 170

ULTRASONIC

Thickness Testing from One Side

Rapid, Accurate, Non-Destructive

VIDIGAGE®

14" or 21" Cathode-Ray Screen with direct-reading scales between 0.005" and 2.5"; accuracy 0.1% to 1.0%.

Detect Laminar Flaws and Lack of Bond

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I N S T R U M E N T S , I N C .**

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AUDIGAGE®

Portable Thickness Testers for ranges from 0.020" to 4" or 0.060" to 12" of steel; accuracy up to 1.0%.

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HARDNESS TESTING SHORE SCLEROSCOPE

Pioneer American
Standard Since
1907



Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000
IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.

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- TENSILE
- CREEP
- STRESS RUPTURE

Joliet Metallurgical Laboratory, Inc.
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PHONE JOLIET 2-3328

LIST NO. 157 ON INFO-COUPON PAGE 170

the GENUINE BRINELL

HARDNESS TESTING MACHINES
made by the Alpha Co. of
Sweden and available from
our stock at New Rochelle

Never approached in
ACCURACY AND
CONSTANCY of cali-
bration . . . at the
standard 3000kg test
load: . . . maximum
error plus or minus
2½ kg

Write for Bulletin
No. A-18



GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3 N.Y.

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the TRUE TEST IS

Taber



TABER
Abrasion
TESTER

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TABER
Stiffness
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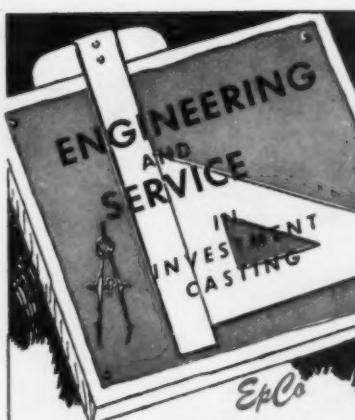
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CASTINGS IN FERROUS AND
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INVAR
CASTING
Special Feature
— Nickel content
held to 35% min-
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maximum

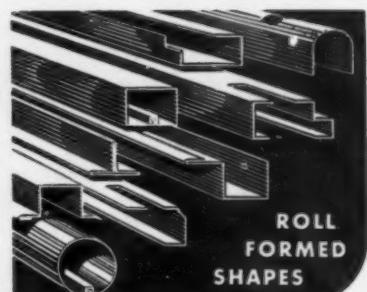
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bottling unit formerly machined
from solid stock. Only finish opera-
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bored hole and drilling and tap-
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PRECISION CASTING CO.

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FORMED
SHAPES

Reduce your assembly problems and costs.
Our shapes continuously formed, with high
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NON-DESTRUCTIVE
COATING THICKNESS TESTER



FAST-ACCURATE
COMPACT-PORTABLE
DIRECT-READING

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- For Metals on Metals
- Non-Conductors on Metals
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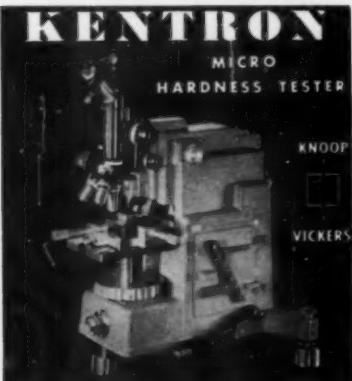
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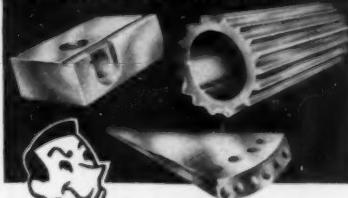
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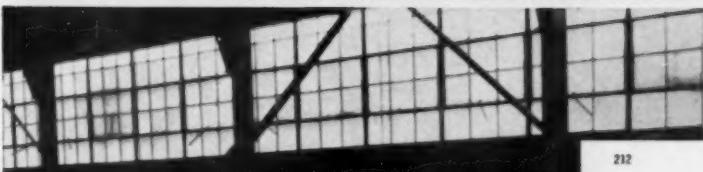
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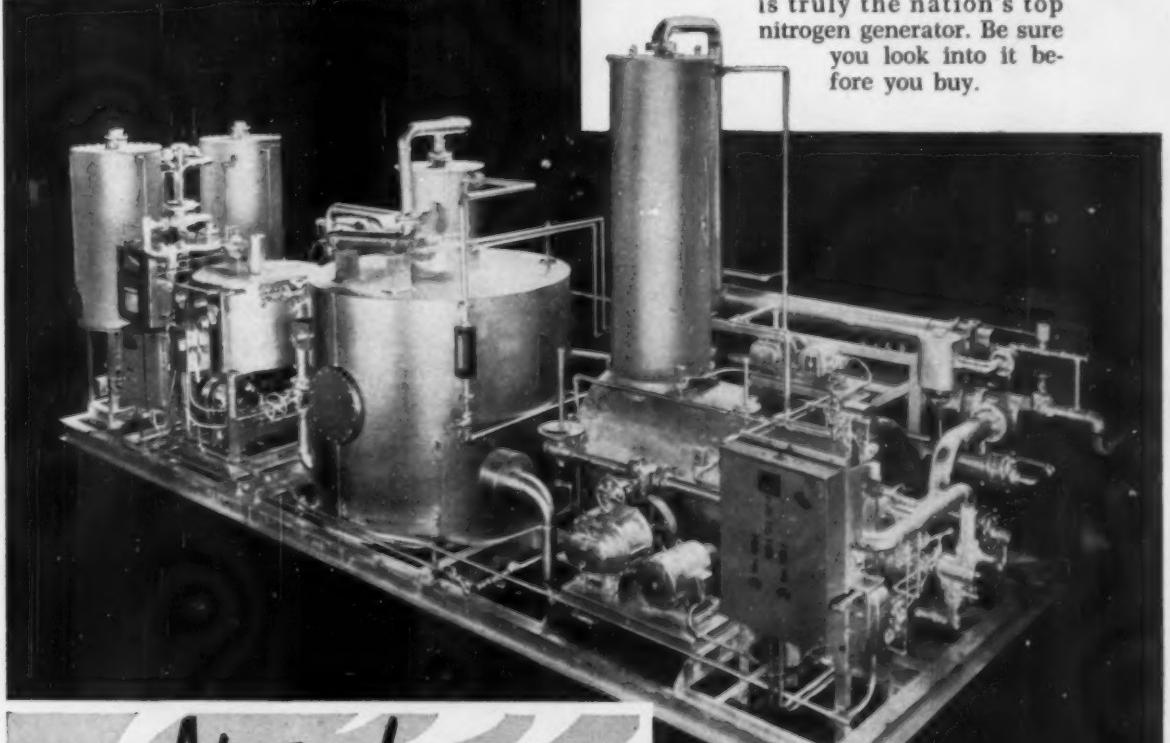
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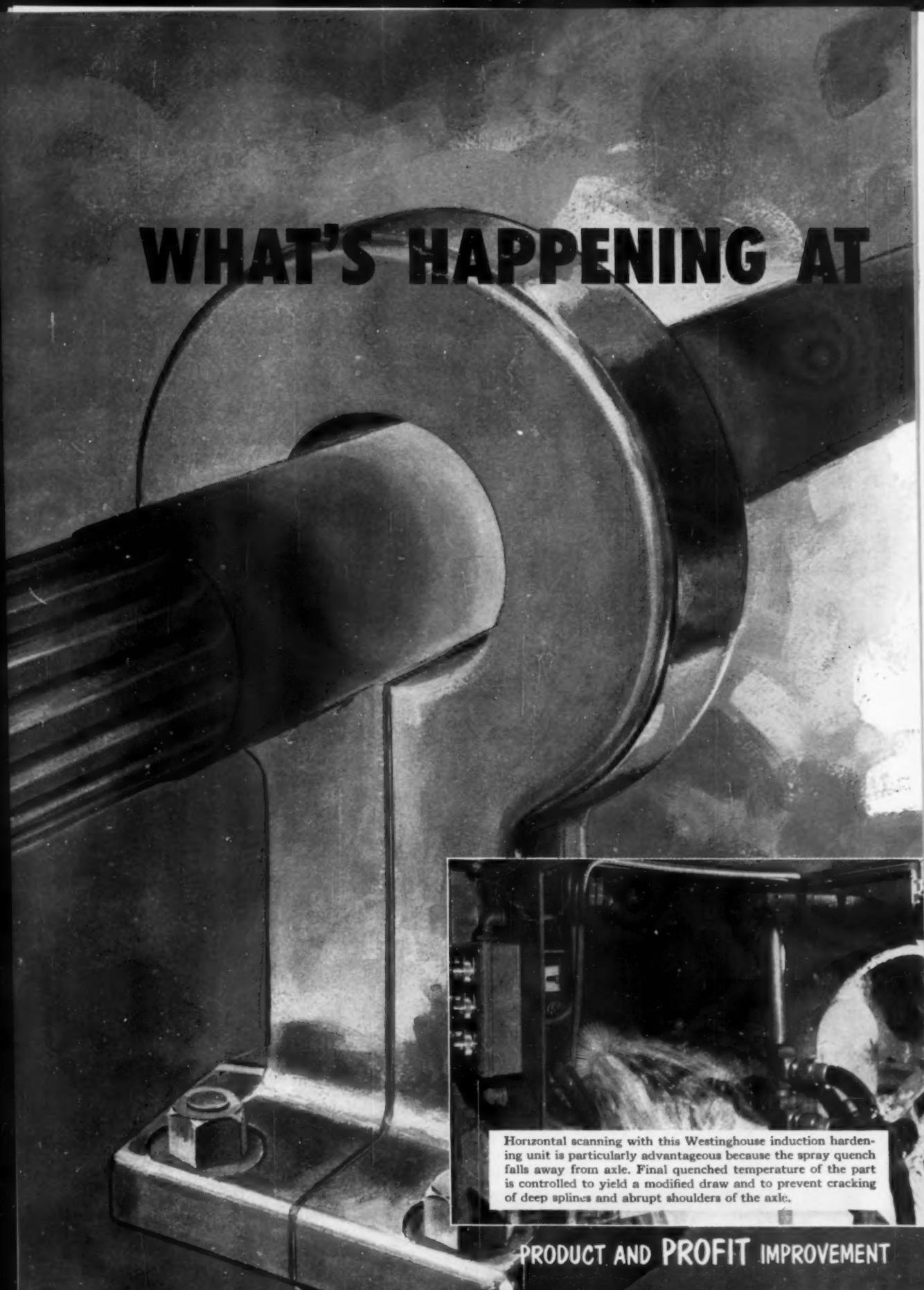


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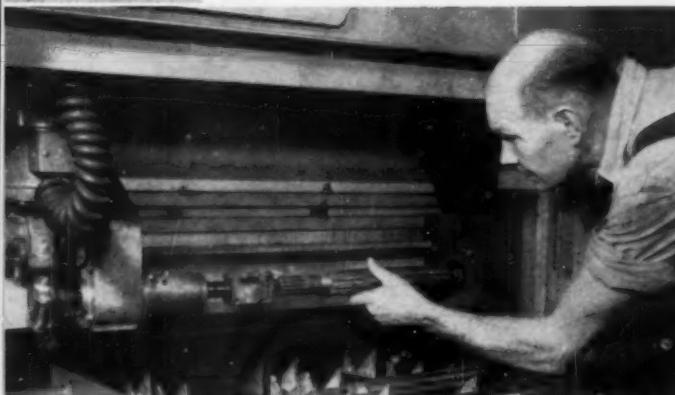
They say that with Westinghouse Induction Heating there is less distortion, therefore faster operation . . . 100% better control of case depth and many savings from the standpoints

of operating and manufacturing. According to the Oliver Corporation, the Westinghouse Induction Heating units have "revolutionized our methods of heating."

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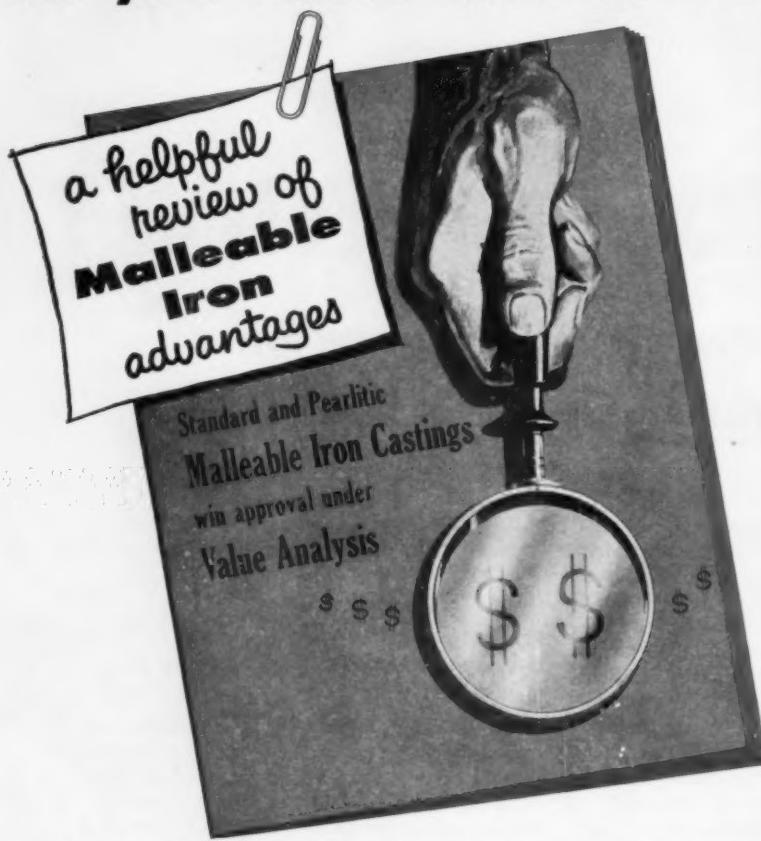
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Role of Carbon in Temper Embrittlement

Digest of "A Study of the Role of Carbon in Temper Embrittlement", by E. B. Mikus and C. A. Siebert, *Preprint No. 39, 1957*.

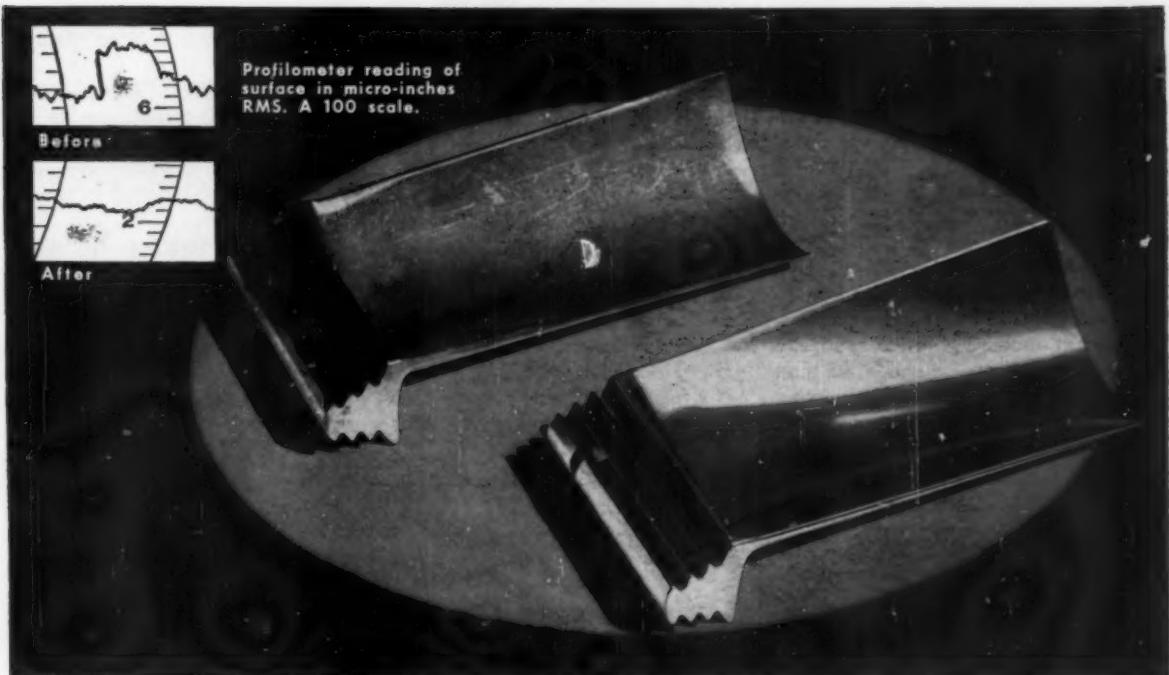
THE PHENOMENON of temper embrittlement was investigated by the authors by electron microscopy and autoradiography using carbon-14. The problem was to determine if microstructural changes which occur during embrittling heat treatment could be assignable causes of brittle behavior. The material chosen for the work was S.A.E. 3140 steel of A.S.T.M. grain size No. 8 and analyzing 0.39% C, 0.78 Mn, 0.28 Si, 0.010 P, 0.019 S, 0.61 Cr, 1.26 Ni and 0.04 Mo.

Impact bars were investigated by electron microscopy. Tough bars were obtained by tempering for 1 hr. at 1250° F. in a salt bath after quenching. The embrittled condition was obtained by an additional treatment of the impact bars for 500 hr. at 850° F. in a vertical muffle furnace. The impact transition temperature was -165° F. for the tempered bars and +19° F. for the bars given the embrittling treatment.

Specimens used in autoradiographic studies were decarburized in moist hydrogen and then recarburized with specific amounts of carbon. This was done by pack carburizing with charcoal and BaCO₃ containing some carbon-14. These samples were then quenched, tempered and embrittled while sealed in an evacuated Vycor tube. A series was embrittled for 100 to 500 hr. at 850° F.

A survey of the literature on the mechanism of temper embrittlement indicated that current theories regard segregation or precipitation effects as probable causes. The electron metallographic investigation was made to determine if carbide morphology is a significant factor in the problem. The autoradiographic work was designed to determine the extent to which carbon segregation could be responsible for temper brittleness. Carbide precipitation effects were also investigated.

Samples for electron metallographic investigation were polished electrolytically in 20% perchloric acid and then etched with ethereal picric



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Temper Brittleness . . .

acid. Collodion was the replica material, palladium-shadowed. Electron micrographs were reproduced at 10,000 \times .

Radiographic specimens were polished mechanically and etched with ethereal picric acid. Autoradiographs, exposed from 1 to 12 days, were examined at magnifications up to 1000 \times . Various etching and exposure times and specific activity levels were used to obtain the most favorable conditions for observing carbon segregation.

The authors report the following:

1. No continuous film of any kind was observed in the prior austenite grain boundaries of a temper embrittled structure developed in S.A.E. 3140 steel samples.

2. Although carbides were observed in the prior austenite grain boundaries of an embrittled structure, it is unlikely that these have any effect on temper embrittlement, since carbides were also found in similar positions in tough samples.

3. Prior austenite grain boundaries revealed by the etchant were grooves between the grains which increased in depth both with etching

time and degree of embrittlement. They were not a staining effect of the etchant.

4. Neither autoradiographic nor electron metallographic studies revealed that carbon atoms or carbides had segregated to the prior austenite grain boundaries of embrittled structures.

Because of their experience the authors propose that temper embrittlement is brought about by a strain developed across prior austenite grain boundaries at the embrittling temperature and that it is a result of contraction of the ferrite lattice when dissolved alloying elements are removed from solution in the ferrite by reaction with the existing minor carbide phase.

S. T. Ross

Transformation Structures in Hypo-Eutectoid Alloy Steels

Digest of "Transformation Structures in Hypo-Eutectoid Alloy Steels", by W. C. Hagel and M. N. Ruoff, Preprint No. 25, 1957.

THE USEFUL mechanical properties of tonnage and specialty steels depend basically upon the structures resulting from commercially practicable cooling rates.

Fundamental principles and experimental facts have been presented to account for the formation of pearlite but further study is needed to explain the formation of pro-eutectoid ferrite and bainite. It is felt that any proposed mechanism should await a better understanding of morphology-controlling factors such as diffusion, interfacial energy, strain energy and nucleation site. Evidence for some of these factors is obtainable with the electron microscope.

Prior investigators have directed their attention to the simple isothermal reactions, and assume correlation with cooling behavior based on the requirement that high and low-temperature transformations are either completely additive or completely independent. However, if the rate of transformation at any temperature depends upon the amount of transformation which has taken place at some higher tem-

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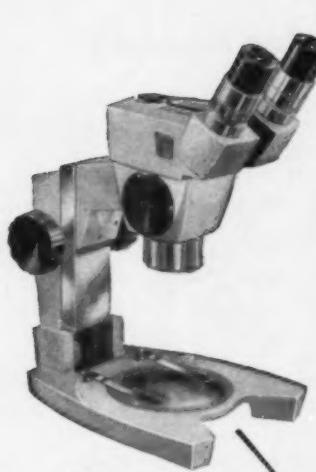
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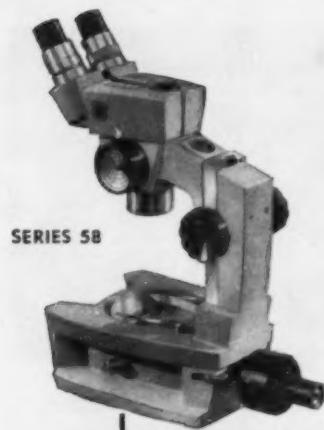
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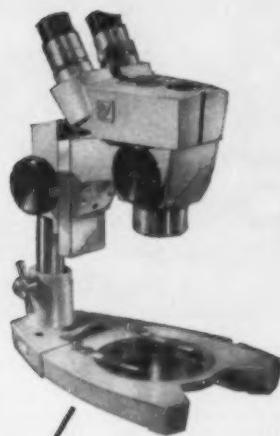
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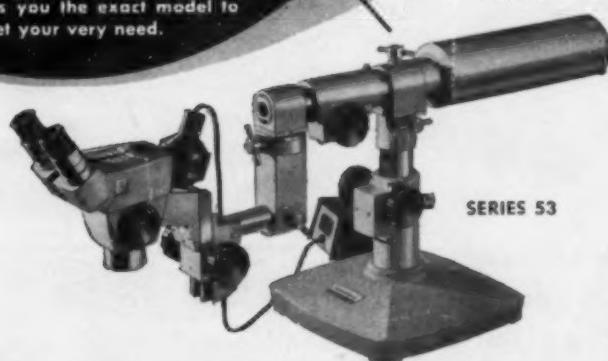
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Cooling Behavior . . .

perature, isothermal transformation curves are inadequate for describing cooling behavior.

Both isothermal and cooling transformation curves were determined for five hypo-eutectoid deep hardening steels, and specimens produced under controlled conditions were given a thorough optical and electron microscopic examination to determine the structural details that are required for mechanistic interpretations.

At high temperatures, the dominating morphology-controlling factors are diffusion and interfacial energy; at low temperatures, strain energy and nucleation site dominate; and at any intermediate temperature all of these factors may be present, and the observed structure depends on their relative influence.

A number of conclusions are drawn from this extensive experimental investigation based on examination by optical and electron microscope of a great number of samples resulting from the isothermal and cooling transformation heat treatments performed.

H. J. ELMENDORF

Study of Stresses in Cermets

Digest of "Temperature Stresses in the Two-Phase Alloy, WC-Co", by J. Gurland, Preprint No. 3, 1957.

ALLOYS of two phases contain stresses which are caused by the difference of coefficients of thermal expansion and elastic properties of the constituents. If, for instance, the microstructure consists of particles of one phase dispersed in a matrix of another phase, stresses appear in both the matrix and the dispersions during the cooling to room temperature from the stress-free state at higher temperature. It is clear that these locked-in stresses must be of major importance in the consideration of the strength of compacts. It is for this reason that their study is of practical significance.

The author presents theoretical and experimental evidence of the magnitude of such microstresses (Continued on p. 182)

This is the twenty-third of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Annealing: Its Uses with Alloy Steels

Broadly speaking, the primary purpose of annealing is to soften steel and make it more workable. Annealing, as applied to alloy steels, may be defined as a process that heats above, and furnace-cools through, the critical range at a controlled, specified rate of speed; or that heats to a point within, and furnace-cools to a point below, the critical range. In either case, the choice depends upon the structure and maximum hardness desired.

The first method produces a lamellar pearlitic structure, while the second creates a spheroidized condition. These will be discussed separately in the following paragraphs:

(1) *Lamellar pearlitic structure.* It should be mentioned at once that this structure can be obtained both as described above and by a modified method known as isothermal annealing. In the isothermal process, the steel is heated above the critical temperature (austenitized), then transformed at a predetermined temperature, which depends upon the analysis. This operation requires two furnaces or salt baths—one for austenitizing, one for transformation.

Lamellar pearlitic structures are generally associated with machinability in carbon ranges from 0.20 to 0.60 pct, provided the hardness does not exceed the optimum maximum Brinell numeral. This is especially true where critical tooling is involved. It is a very versatile structure, as it gives best results in such operations as broaching, tapping, threading, deep drilling, boring, milling, and tooling as applied on

single- and multiple-spindle bar automatic machines.

(2) *Spheroidized structure.* There are two general fields of use for this type of structure when alloy steels are employed. In the low and medium carbon ranges, spheroidization is necessary for cold-shaping operations, such as heading, extruding, drawing. In the higher carbon ranges (over 0.60 pct), it is mandatory where machining is involved, because it tends to lower the hardness of the steel.

As noted elsewhere in this discussion, both lamellar pearlitic and spheroidized structures can be created through annealing. If you care for more details about these and other uses of annealing, and the results to be expected, by all means consult with our technical staff. Bethlehem metallurgists will gladly help you work out any problems. And when you are ready for new supplies of alloy steels, Bethlehem can offer the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through No. XX, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 20 subjects in the series are now available in a handy 36-page booklet, and we shall be glad to send you a free copy.

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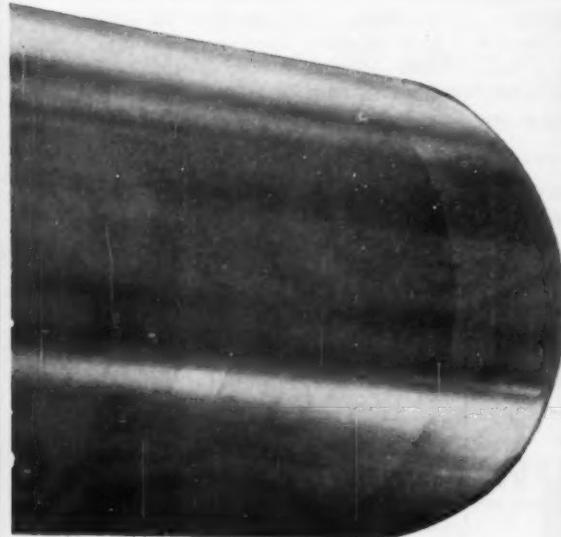
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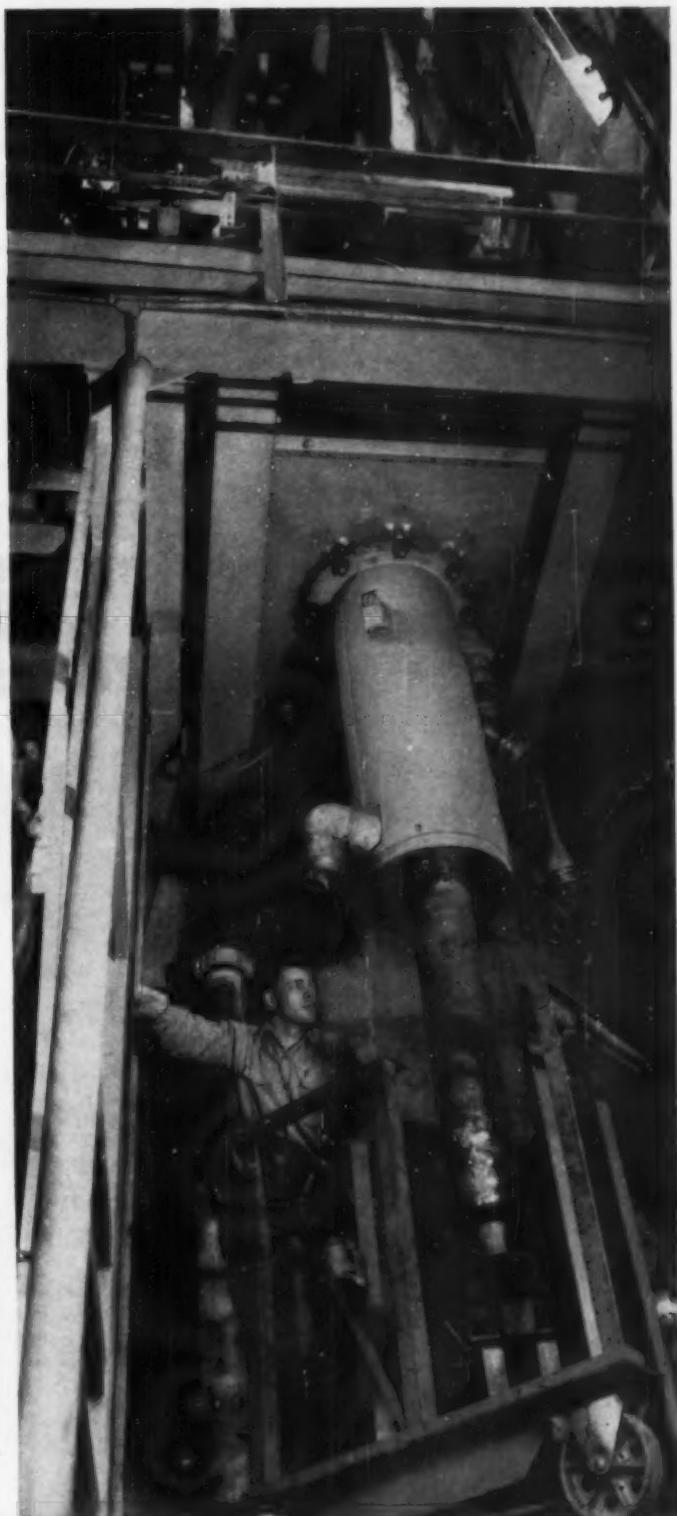
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Stresses in Cermets . . .

(tessellated stresses) in terms of a series of tungsten carbide dispersions in a cobalt-rich solid solution as a binder. The physical constants are particularly well suited for such a study. The coefficient of thermal expansion differs greatly between 100% tungsten carbide (5.4×10^{-6} in. per in. per °C.) and 100% cobalt (12.3×10^{-6} in. per in. per °C.) while Young's Modulus differs in the opposite direction, namely 102×10^6 psi. for 100% WC to 30×10^6 psi. for 100% Co.

It is shown experimentally that

the stresses on the WC phase vary from compression, when the phase is completely surrounded by the cobalt matrix (say 35% by volume), to tension when the cobalt fills only the interstices between closely pressed WC particles. In the former case, the cobalt with its higher thermal contraction shrinks about the WC particles during the cooling operation from the sintering temperature, 1400° C. (2550° F.), and thus induces compression in the particles. In the latter case the cobalt, caught in the spaces between WC grains, tends to shrink away from the interface and thus induces tension on the WC particles.

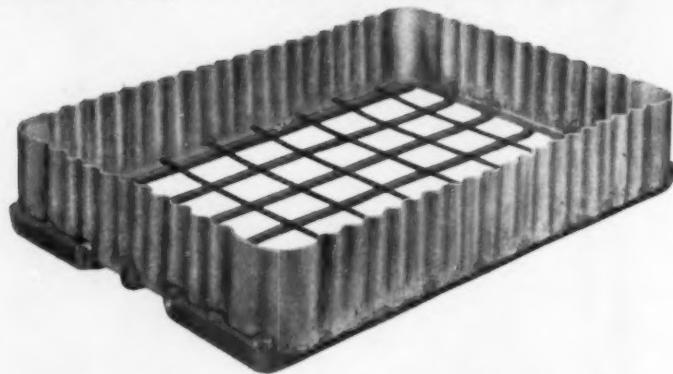
The classical solution of the theory of elasticity applies to the case where one round homogeneous particle is enclosed in an infinite homogeneous matrix. With this as a base the author proceeds to X-ray techniques in order to measure stresses in a series of WC-Co compacts ranging from 5 to 37% cobalt by volume. The (211) diffraction line of the tungsten carbide was found suitable as to strength and sharpness. Both recording X-ray spectrometer and back-reflection camera techniques were employed with a resulting precision of interplanar spacings of within 0.0001 Angstrom unit.

In another series of experiments the grain size of tungsten carbide was varied and the resultant effect with respect to the induced stresses was studied. It was shown that the lattice spacing decreases with increasing grain size (for a compact with 10% cobalt by volume) indicating a reduction in tensile stresses. At higher cobalt contents, where the WC particles are under compression, this effect is much less marked.

The X-ray results represent a statistical average of the strains in the carbide lattice and do not provide a more detailed insight into the state of stress near the interfaces which is complicated by geometry and anisotropy of the WC grains. The results do, however, show good agreement with the theoretical prediction and add another piece of information to the study of stresses in cermets.

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Dislocation Theories Applied to Upper Yield Stress

Digest of "The Effect of Rate of Stress Application and Temperature on the Upper Yield Stress of Annealed Mild Steel", by J. A. Hendrickson and D. S. Wood, *Preprint No. 27*, 1957.

PREVIOUS INVESTIGATIONS have shown that mild steel exhibits a distinct delay time for the initiation of yielding when subjected to rapidly applied constant tensile stresses in excess of the static upper yield stress. Also, the basic concepts of a dislocation theory of yield point phenomena have been developed.

The dislocation theories may also

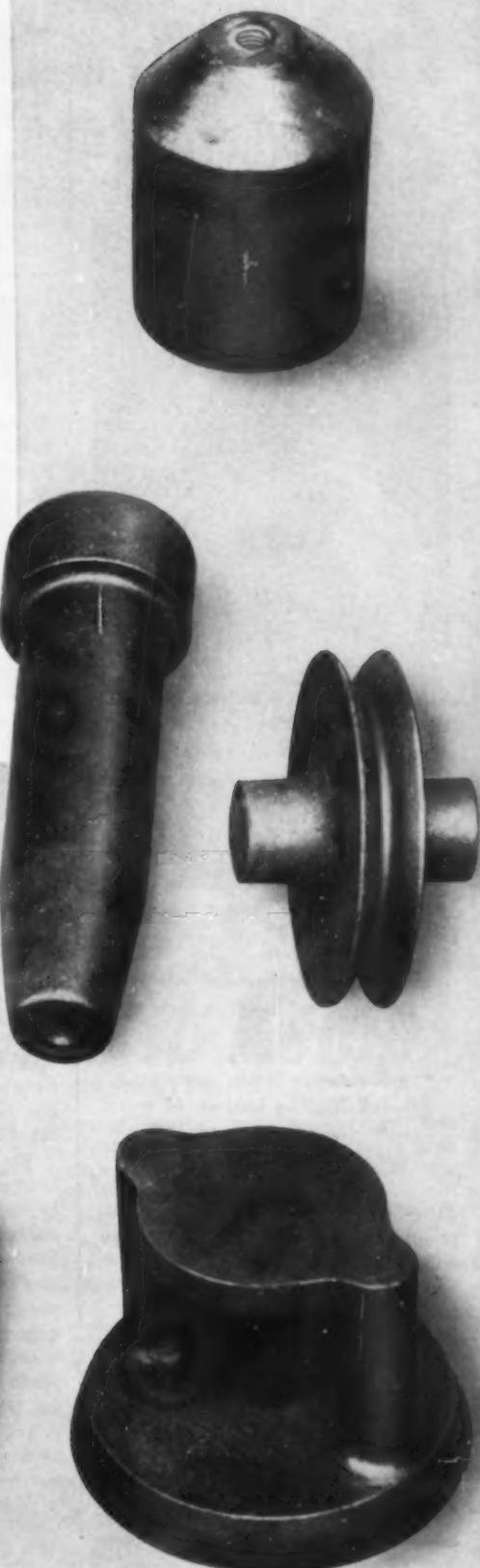
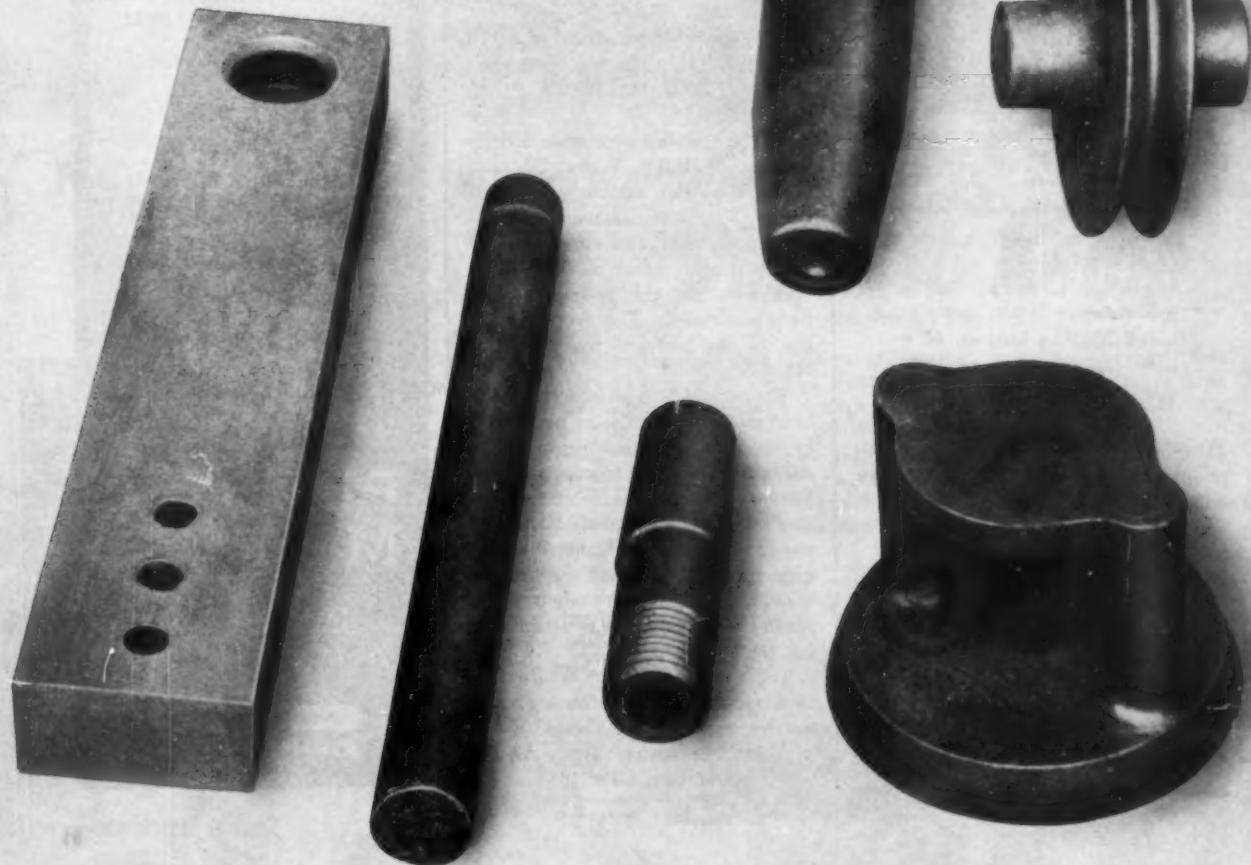
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Upper Yield Stress . . .

be employed to derive expressions for the upper yield stress and the time of yielding as functions of temperature under types of loading other than rapidly applied constant stress.

Two theoretical predictions of the upper yield stress of an annealed low-carbon steel as a function of rate of stress application and temperature are presented in this paper. Both predictions are based upon the basic concepts of the dislocation theory of yield point in body-centered cubic metals containing interstitial solutes. The difference between the two predictions arises from differences in the various assumptions and approximations which are made in the derivations. Quantitative predictions of the upper yield stress are obtained by evaluating the undetermined constants of the two forms of the theory by means of experimentally determined values of the delay time for yielding under constant stress.

The upper yield stress of an annealed low-carbon steel was determined experimentally under various constant rates of stress application ranging from about 10^2 to 10^7 psi. per sec. at temperatures of -110 and -200° F. The steel analyzed 0.17% C, 0.39% Mn, 0.017% P and 0.040% S.

The specimens were annealed by heating at 1600° F. for 50 min. followed by slow cooling in the furnace. The entire annealing treatment was done in an atmosphere of dry hydrogen after all machining operations on the specimens had been completed. The average grain size of the material was A.S.T.M. No. 6.5.

The tensile tests at constant rates of stress application were performed by means of a hydro-pneumatically operated rapid load tensile machine. This machine is capable of rates of load application up to about 10^6 lb. per sec. Since the diameter of the gage section of the test specimen is 0.300 in., the maximum rate of stress application attainable is about 10^7 psi. per sec.

The applied load was determined as a function of time during each test by means of a calibrated dynamometer employing type AB-14,

(Continued on p. 188)

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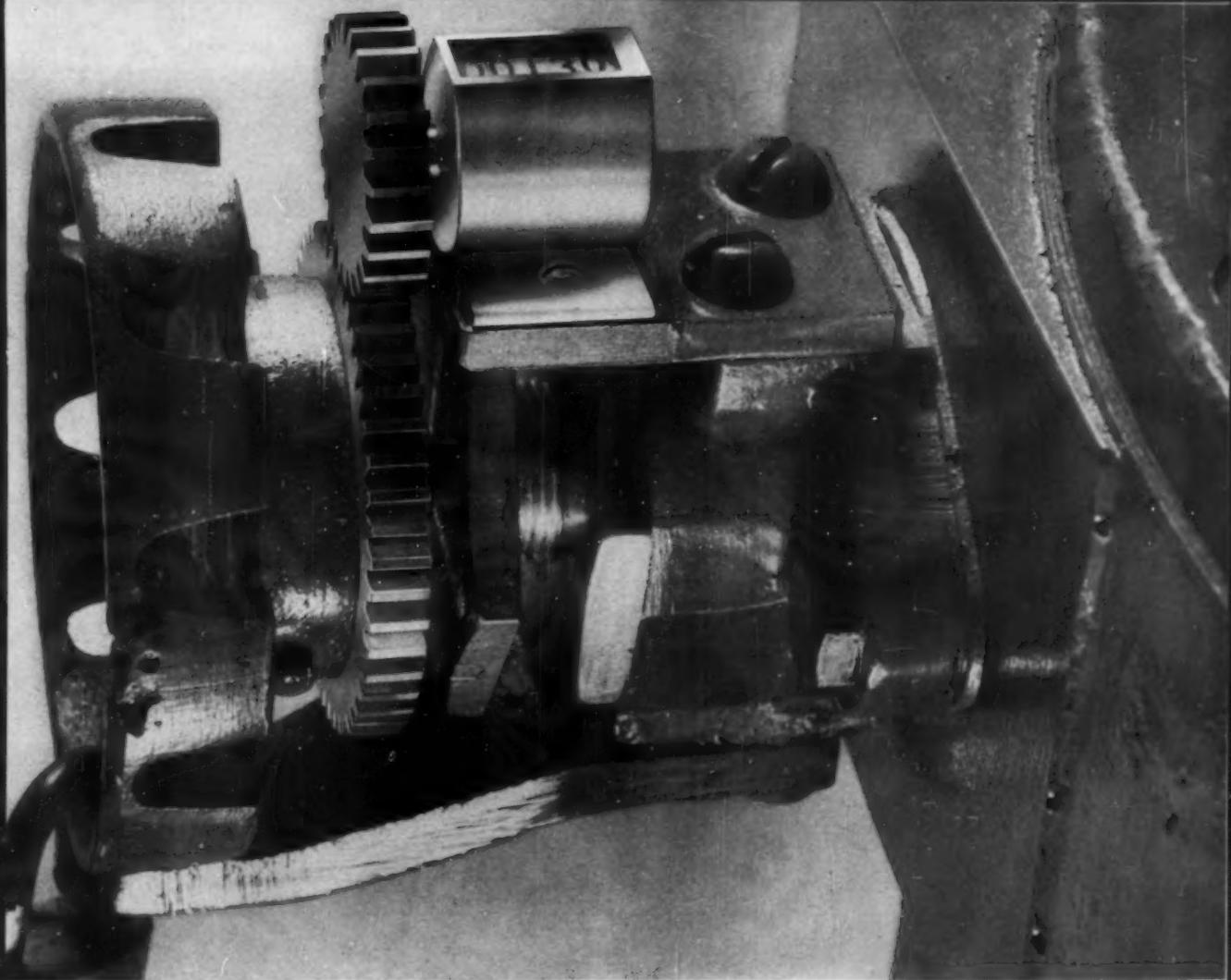


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Upper Yield Stress . . .

SR-4 strain gages. The signal from the dynamometer was amplified and recorded. The time resolution of the recording system is about ± 1 millisecond at the maximum recording rate. The load acting on the specimen at any time could be determined to within an estimated over-all error of about 4%. The onset of macroscopic yielding is characterized by a sud-

den decrease of load which is readily detectable on the test records.

The low test temperatures were provided by a bath of Freon-12 held in a suitable container surrounding the specimen and portions of the grips. Dry ice in the Freon bath brought the temperature to -110° F., and liquid nitrogen in a concentric container surrounding the Freon bath provided the test temperature of -200° F. An electrical heater in the bath controlled the temperature of

the specimen. The total temperature difference along the specimen gage length was less than $\pm 5^{\circ}$ F. for the tests at -200° F., and less than $\pm 1^{\circ}$ F. at -110° F. The temperature variation was $\pm 10^{\circ}$ F. or less during the tests at -200° F. and less than $\pm 1^{\circ}$ F. during the tests at -110° F.

The experimental measurements of the upper yield stress as a function of the applied stress rate at the two temperatures are in good agreement with the predictions of both forms of the theory mentioned above. This indicates that the general aspects of the dislocation theory of yielding are correct. The experimental data available at the present time are not sufficient to evaluate the relative merits of the several specific theories which may be constructed by employing different detailed dislocation models. However, these theories are capable of predicting the upper yield stress of a mild steel subjected to various constant rates of stress application and temperatures.

The theory may also be employed to predict the upper yield stress under more complex stress-versus-time conditions. Furthermore, the experimental data required for quantitative evaluation of the theory could be obtained from tests at constant rates of stress application, rather than from delay time measurements. In this case the delay time could be predicted as a function of applied stress and temperature.

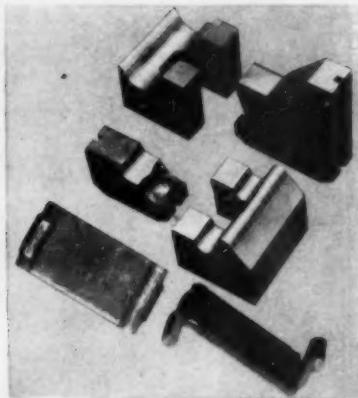
D. J. GIRARDI

Deformation of Uranium During Thermal Cycling

Digest of "Microstructural Changes of Uranium Upon Thermal Cycling", by L. T. Lloyd and R. M. Mayfield, Preprint No. 35, 1957.

ONE OF THE important problems encountered by metallurgists working on fuel elements for nuclear reactors is the abnormal macroscopic deformations which occur in uranium and its alloys. The authors studied the microstructural changes accompanying the dimensional changes due to thermal cycling of the orthorhombic phase of uranium. Most investigators agree that this type of dimensional instability arises from intercrystalline stresses devel-

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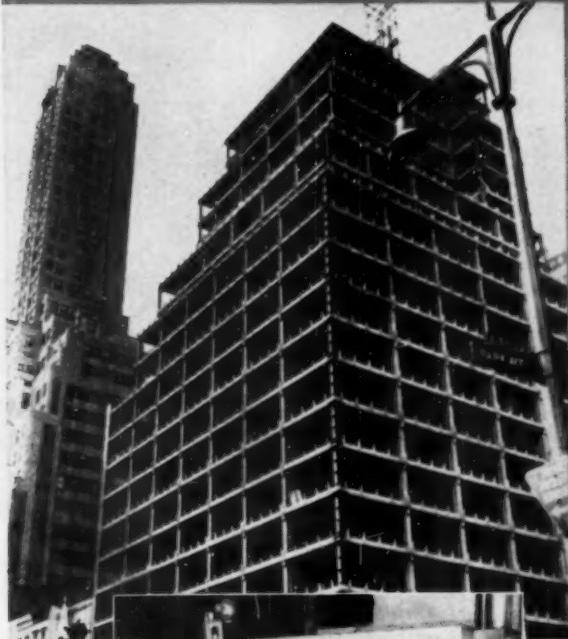
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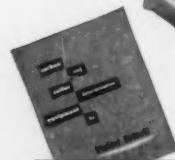
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Uranium Deformation . . .

opened by the anisotropic thermal expansion of the orthorhombic phase. Burke, Howe and Lacy ("Dimensional Instability of Uranium," Knolls Atomic Power Laboratory, TID-5044) have proposed a "thermal ratcheting" mechanism which makes the deformation irreversible.

The authors studied three types of uranium — coarse-grained, highly purified uranium, to establish the metallographic aspects of deformation during thermal cycling; fine-grained, high-purity uranium; and some commercial-purity, fine-grained uranium.

Upon cycling the coarse-grained uranium between room temperature and 500° C. (930° F.), the major intragranular deformation occurred by slip, mainly on (010)-[100] with cross-slip in some grains and some secondary {110} - <110>. There was also an increase in {130} twinned material but no increase in the number of twins. These crystallographic evidences of slip and twinning occurred after the first treatment of 15 cycles and a greater number of cycles did not result in additional mechanisms of deformation—merely an enhancement of the metallographic evidence of deformation. There was also evidence of subgrain formation.

In the fine-grained samples there was evidence of subgrain formation, grain-boundary migration and grain-boundary sliding after thermal cycling as well as slip and twinning. The amount of deformation resulting from twinning was very minor. There was no evidence of voids in the high-purity uranium even after 3000 cycles, but there was evidence of grain growth.

A sample of commercial-grade uranium thermal cycled for 3000 cycles showed a unidirectional growth of approximately six times the sample's original length. The outstanding microstructural change was the presence of an abundance of voids. There was also an increase in grain size but no change in preferred orientation.

The authors point out the close similarity between the deformation mechanisms in thermal cycling of uranium and those in the creep of metals. Both processes are associated

(Continued on p. 196)

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Paul R. Brucker, Metallurgist, Crucible Steel Co. of America, Midland, Pa., joins Mr. Edelman in preparation of the first five lessons of "Elements of Metallurgy". *Lesson No. 1* lays the groundwork for an understanding of metallurgy in an examination of the structure of metals, the behavior of atoms and molecules. Following this study of the chemical nature of metals, *Lesson No. 2* concentrates on the physical side and the problems of measurement, expansion, mass and energy, heat transfer and the like.

The chemical changes, or reactions, that take place between elements, between compounds, or between elements and compounds are discussed in *Lesson No. 3*, with *Lesson No. 4* reviewing what happens in any given instance with specific elements in chemical reactions and with the effects of heat and temperature. *Lesson No. 5* points out that the chemical reactions that involve oxides are the foundation for the chemistry of refractories, smelting and combustion, and these are discussed.

Smelting and refractories and metal refining are subjects of *Lessons 6 and 7*, and are prepared by Edward D. Hinkel, Jr., Metallurgist, Carpenter Steel Co., Reading, Pa., with Mr. Edelman. Various smelting processes are described and necessary equipment is illustrated with cut-away charts and pictures. Refining processes that are required to produce a finished alloy from the metal produced by the smelting operations are then presented.

In *Lesson No. 8*, William McNeill, Electrochemist at Frankford Arsenal joins Mr. Edelman in a thorough discussion of electrolytic metallurgical processes, while in *Lesson No. 9*, Harry W. Antes, Metallurgist at Frankford cooperates with Mr. Edelman in an examination of what takes place when refined metals that are poured into ingot molds change from liquid to solid. In *Lesson No. 10*, Leonard Rubin, Research Assistant at Massachusetts Institute of Technology, writes with Mr. Edelman a more detailed discussion of metals structures in this solid state.

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Another valuable study tool and reference feature of each course is the ASM Metals Handbook, supplied free as a regular part of your course. Upon enrollment, you will receive (1) the ASM Metals Handbook; (2) the attractive MEI Binder; (3) the first two study course lessons, and instructions for study. Then in your own spare time you complete your first lesson, return your quiz questions to the instructor assigned to you at MEI Headquarters. Then you can begin *Lesson No. 2*. Meanwhile, your MEI instructor goes over your answers to the *Lesson No. 1*, carefully grades and makes suggestions for you. These suggestions and comments are then returned to you, along with the *Lesson No. 3*. And so on. You always have a lesson in your hands. You have one going to M.E.I. and M.E.I. has one coming to you. This rotation is maintained to conveniently fit in with your own plans, your own available time.



HEAT TREATMENT OF STEEL

One of the basic requirements in the processing of steels is their correct and efficient heat treatment. This outstanding, up-to-the-minute steel treating course fills the bill exactly with 15 authoritative lessons prepared by George F. Melloy, Research Engineer, Bethlehem Steel Co., Bethlehem, Pennsylvania.

Scores of pictures, charts and tabular matter are presented by Mr. Melloy in this practical coverage of all important aspects of the Heat Treatment of Steel. You will find this an interesting, helpful study, and a handy, day-by-day reference in the future.

Steel is a versatile material, Mr. Melloy points out in *Lesson No. 1*. He discusses what steel is, what properties make it useful and important, how these properties are measured and evaluated. He covers elasticity, plasticity, tensile testing and other important aspects. *Lesson No. 2* discusses the structure and mechanical properties . . . constitution of steel . . . effect of alloying elements and of heat treatment on mechanical properties.

Lesson No. 3 discusses relationship between structure of steel and its mechanical properties and the two basic methods of controlling structure and hence mechanical properties. *Lesson No. 4* describes annealing of steel—process of heating and cooling to reduce hardness . . . discusses procedures of altering and controlling structure of steel.

Hardening of steel is the subject of *Lesson No. 5*, and Mr. Melloy points out that only in modern times have these principles been understood. Maximum benefits from hardening were not realized until fairly recently. He shows how you can take full advantage of steel with proper hardening processes. *Lesson No. 6* continues a discussion of hardness and the factors involved . . . tests . . . and application of hardenability data.

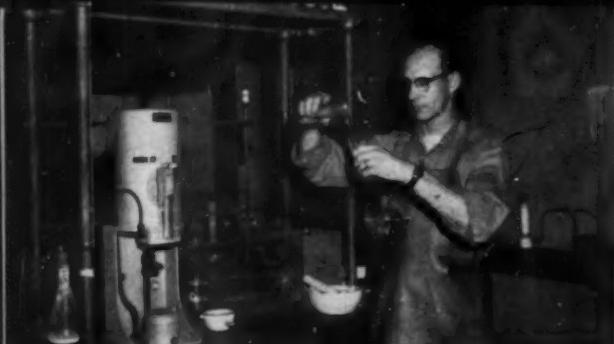
Factors affecting hardness and hardenability are presented in *Lesson No. 7*, and include effects of carbon . . . alloying . . . quenching and miscellaneous factors. *Lesson No. 8* brings you up-to-date on tempering . . . its three stages . . . effect of temperature and time, of chemical composition and structure . . . of cooling practices.

Surface hardening of steel is discussed in *Lesson No. 9* and includes flame, induction and liquid salt hardening. Heat treatment of cast iron and cast steel described in *Lesson No. 10*, with *Lesson No. 11* discussing protection during heat treatment against decarburization and scaling. Heat treating furnaces, fuels and temperature control are reviewed in *Lesson No. 12*.

Lesson No. 13 outlines the failures and defects to look out for in heat treatment, and *Lesson No. 14* describes grain size—its control and effect. Final *Lesson No. 15* deals with the important areas of tools steels—water hardening, shock resisting, nondeforming, hot work and high speed steels.

Mr. Melloy's work on this outstanding course is backed by long years of experience at Bethlehem Steel Company. He is a graduate of Lehigh University with a degree in Metallurgical Engineering, has been an instructor at the Bethlehem Center of the Mineral Industries Extension Services, Pennsylvania State University.

THESE COURSES



"... Makes my work more interesting . . ." says Student

Glen C. Boyce, Chemist and Foreman of the Iowa Malleable Iron Co., Fairfield, Iowa, selected "Elements of Metallurgy" on his M.E.I. study. He writes "I am enjoying this course very much. The fact that the study material parallels my work makes both my work and studies a great deal more interesting."



HIGH TEMPERATURE METALS

One of the most timely home study courses available anywhere . . . this course on High Temperature Metals by Dr. C. L. Clark, Metallurgical Engineer, Timken Roller Bearing Co., Canton, Ohio, authoritatively covers a broad, vitally essential area.

Fifteen lessons are packed with updated information, filled with 287 helpful illustrations. Keyed to references in the ASM Metals Handbook (a part of the study course), Dr. Clark provides a step-by-step climb to expert knowledge.

Jet engines, modern automobiles . . . the electricity you use . . . the high quality gasoline . . . all these are made possible by high temperature metals, and the surface of tomorrow's use is yet to be scratched. Here is a field where the *expert you can become* knows no limits.

Lesson No. 1 traces the growth of high temperature metallurgy, discusses today's most pressing problems in this interesting field. Relates the importance of high temperature metals in three major metal using industries. *Lesson No. 2* demonstrates, simply and practically, the many tests that can be made . . . their importance. *Lesson No. 3* shows the relationship between room temperature properties to high temperature alloys . . . carbide formation . . . temper brittleness . . . stability. *Lesson No. 4* goes into corrosion . . . hot hardness . . . thermal shock resistance. *Lesson No. 5* discusses allowable working stresses . . . factor for safety . . . design for long service life . . . ASME stresses . . . Lab Data. *Lesson No. 6* deals with melting charge constituents . . . chromium, molybdenum, nickel, titanium, tungsten, vanadium, cobalt, silicon, and many others. *Lesson No. 7* presents the factors that influence high temperature strength . . . *No. 8*, the low and intermediate alloy steels . . . *No. 9*, the straight chromium stainless steels . . . *No. 10*, the austenitic iron-nickel-chromium steels . . . *No. 11*, high temperature superalloys . . . *No. 12*, the low alloy steel for highly stressed high temperature applications . . . *No. 13*, representative service failures . . . *No. 14*, metal properties at processing and fabricating temperatures . . . *No. 15*, selection of alloys for specific application. These helpful, practical lessons . . . the suggestions and comments of your M.E.I. Instructor will bring you up-to-date on high temperature metals technology.

The quality and authority of this course is the natural result of its learned preparation by Dr. Clark, who is a graduate of the University of Michigan with B.S., M.S. and Ph.D. degrees. After lecturing in Metallurgical Engineering at the University, he joined the Steel and Tube Division of the Timken Roller Bearing Company, where he is now Metallurgical Engineer, Special Steel Developments. He has developed a number of alloys, holds several patents, has published 100 papers. He is active in many societies and on many technical committees, has received a citation from his University as a distinguished alumnus.



Executives, engineers, supervisors and production men are taking this in-plant training course on the "Elements of Metallurgy" at Cleveland Pneumatic Tool Co., Cleveland. Dr. Anton deSalas Brasunas, Director of Metals Engineering Institute is teaching this class of 22 students. Training Directors and employers have shown great interest in these metals training courses for management, engineering, production and sales executives.



TITANIUM

Millions of dollars have been poured into research and development of Titanium in the United States, England, Japan and other countries since it was first industrialized in 1948. Here is an important new metal of industry . . . one of the most interesting . . . one where firsthand information can be vital to the individual who wants to grow with this great industry.

Authorities throughout the world have been generous in their aid in creating this titanium course . . . it has been prepared by experts throughout the United States, with editorial direction by Dr. Walter L. Finlay, Vice President and Manager of Research, Rem-Cru Titanium, Inc., Midland, Pa.

This course summarizes the metallurgy and technology of titanium . . . provides a detailed picture of where titanium is today, the direction in which it is headed. Each of the 15 lessons covers an important aspect of titanium technology.

In *Lesson No. 1*, Dr. Finlay describes characteristics of titanium, its properties . . . strength-to-weight, tensile strength, crippling strength, corrosion resistance, thermal conductivity and expansion . . . and many applications.

R. L. Powell, Supervisor, Process Research Division, Titanium Metals Corporation of America, Henderson, Nevada, prepared *Lesson No. 2* on the extractive metallurgy of titanium. He discusses production from titanium dioxide, from titanium tetrachloride . . . describes purification, chemical reduction, electrolytic reduction.

Lesson No. 3, by Dr. Finlay, surveys titanium-base alloys . . . gives the ABC's of titanium alloys . . . their structure, heat treatment, etc. In *Lesson No. 4*, Dr. Robert I. Jaffee, Chief, Nonferrous Physical Metallurgy Division, Battelle Memorial Institute, discusses physical metallurgy . . . describes important alloying elements and major contaminants. Dr. Jaffee continues in *Lesson No. 5* with a discussion of beta transformation, heat treatment and thermal stability.

Physical and mechanical properties of titanium are presented in *Lesson No. 6* by D. R. Luster, Chief Supervisor, Research Department, Rem-Cru Titanium, Inc. This lesson reviews what is now known of these important properties and indicates the probable properties that can be expected from yet-to-be developed alloys.

Mr. Luster discusses the metallurgy of titanium in *Lesson No. 7*, and in *Lesson No. 8*, Dr. Finlay describes melting, casting and the powder metallurgy of titanium. Mill processing is covered in *Lesson No. 9* by two experts . . . Dr. Lee S. Busch, Director of Research and Richard J. McClintick, both of Mallory-Sharon Titanium Corporation, Niles, Ohio.

Machining and grinding of titanium is detailed in *Lesson No. 10* by John P. Catlin, of Rem-Cru Titanium, Inc., and in *Lesson No. 11*, George C. Kiefer, of Allegheny Ludlum Steel Corporation, Brackenridge, Pa., discusses corrosion resistance, surface conditioning and chemical analysis.

Final four lessons give outstanding coverage of joining operations, by Glen E. Faulkner, Research Engineer, Battelle Memorial Institute . . . airframe designs, manufacture and uses, by Gordon A. Fairbairn, Supervisor, Materials and Processes, North American Aviation, Inc., Los Angeles . . . titanium jet engine design, by M. E. Cieslicki, Supervisor, Materials Control, General Electric Company, Cincinnati . . . latest developments and trends, by W. Stuart Lyman and E. W. Cawthorne of Titanium Metals Laboratory.

Here is a study course written by outstanding experts, edited by a recognized authority, Dr. Finlay, a graduate of Lehigh University, with a Master's Degree and a Doctor's Degree in Metallurgical Engineering from Yale University. Prior to his association with Rem-Cru, Dr. Finlay was Supervisor of Chemical and Metallurgical Research for Remington Arms Company.

NOW AVAILABLE

Today, the story of the Metals Engineering Institute is dramatized in the long columns of classified advertising. Trained men—*wanted!* Engineers—*wanted!* Industry needs skilled help, needs it badly—and nowhere is this need more severe than in the great industries that produce and use metals.

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Today, then, men who want to get ahead in the giant metal industry . . . men who *want* to know about metals . . . men like you . . . can study, in your own spare time, the authoritative, the new shaped-by-industry courses—at home or on-the-job.

You can solve—and solve correctly the problems that involve metals . . . you can forge to the front, assure *your* success with the outstanding study courses that are ready for you—now. You can have confidence in ASM and in the assurance I give you that MEI will assist you in every way.

Anton deSales Brasunas

Anton deSales Brasunas, Director
METALS ENGINEERING INSTITUTE

Dr. Anton deSales Brasunas was appointed Director of the Metals Engineering Institute after a long search for just the right man, by education and experience, would most ideally qualify for this important post. Dr. Brasunas came to MEI from the University of Tennessee where he was associate professor of metallurgical engineering. Prior to that time, he was associated with the Oak Ridge National Laboratory and with Battelle Memorial Institute. He is a graduate of Antioch College, received his MSc. degree from Ohio State University, his Sc.D. degree from Massachusetts Institute of Technology.



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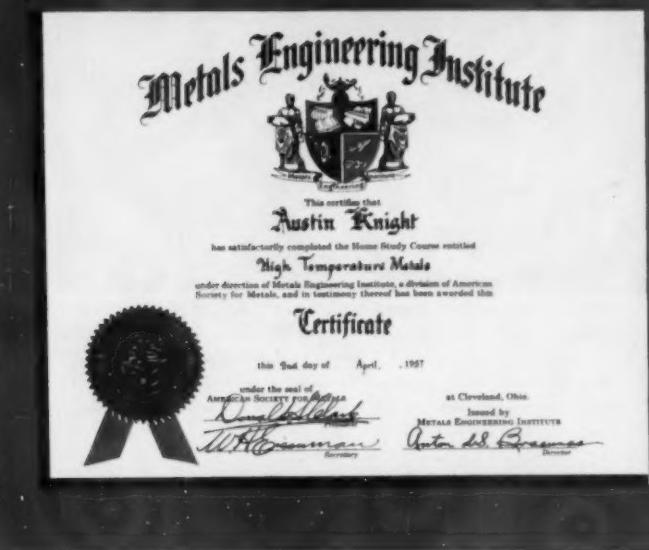
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- Resistance Welding
- Basic Openhearth Steelmaking
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Certificate of the Metals Engineering Institute individually engrossed for each graduate and beautifully encased for home or office.

MEMO Training Directors and Employers

MEI Study Courses are ideally adapted for in-plant, on-the-job or after-hours training. Cleveland Pneumatic Tool Co. and Wallingford Steel Co., for example, are making excellent use of the "Elements of Metallurgy" and the "High Temperature Metals" courses, respectively. Other courses ready now cover Heat Treatment and Titanium.

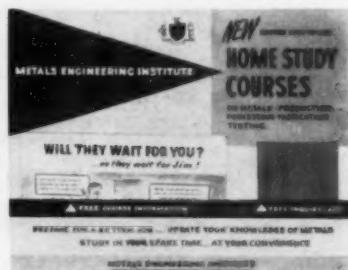
Instructors can be provided if desired or study courses can be presented by your own metals expert, with full assistance and cooperation from MEI Headquarters Staff.

These Courses help your Sales Executives gain greater appreciation of customers metals problems . . . helps Production Men improve and advance in their work . . . Engineers can specialize or take refresher courses that will update their knowledge . . . Management in the midst of metals problems may benefit from sitting-in on these courses.

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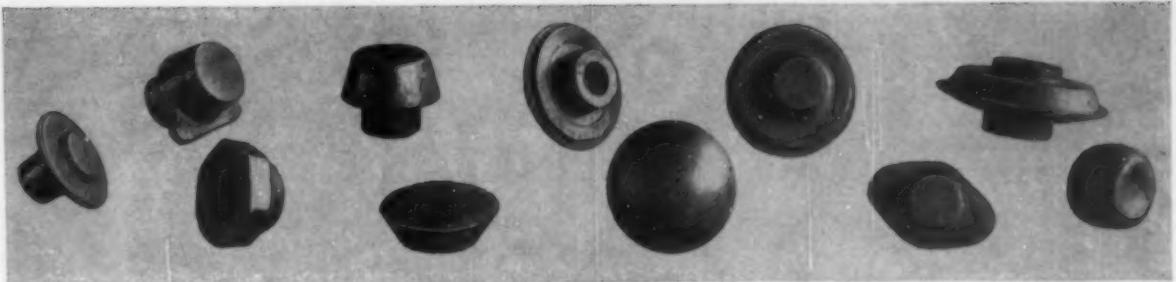
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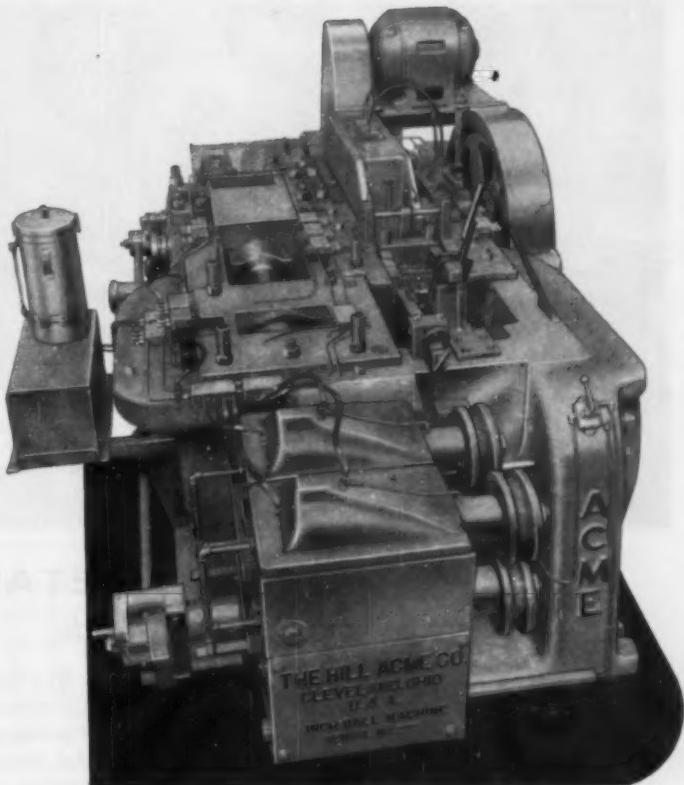


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Uranium Deformation . . .

ated with intragranular slip and in some cases twinning, subgrain formation, grain-boundary migration and grain-boundary sliding. The stresses which cause the deformation on thermal cycling arise from the anisotropic thermal expansion of uranium and the disorientation between adjoining grains and the relative position of the grain boundary.

The work performed by Mayfield, "Effects of Cycling Variables Upon Growth Rate of 300° C. Rolled Uranium", \ominus Preprint No. 37, 1957, is cited to illustrate the

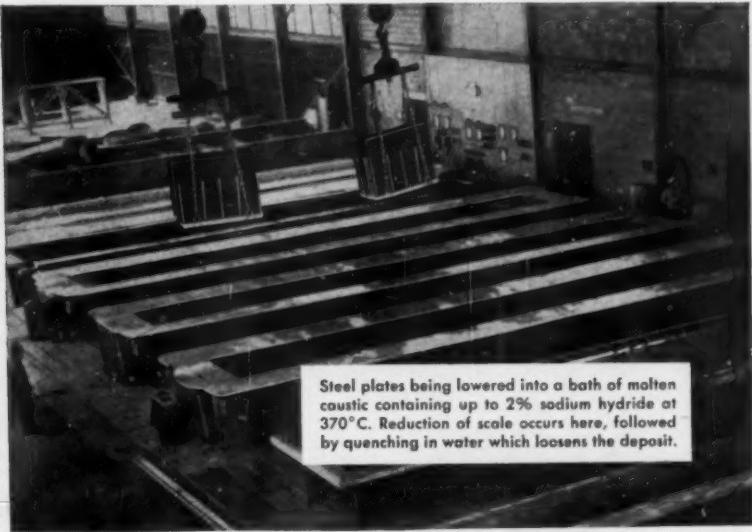
similarity of creep deformation and thermal cycling deformation. For example, Mayfield found maximum growth in highly textured uranium with slow heating and fast cooling rates, whereas fast heating and slow cooling resulted in minimum growth. Presumably the longer period of time associated with slow heating enables the material to elongate by creep to a greater extent under the internal stresses.

The large unidirectional growth can be likened to the dimensional changes which occur upon application of an external tensile stress in a creep test. The higher the upper cycling temperature for a given tem-

perature range, the greater the growth, similar to the higher creep rates which occur at higher creep temperatures. Also if the upper cycling temperature is below 350° C. (660° F.), the thermal cycling growth is small and this would correspond to temperatures below which polygonization does not occur and creep is negligible.

The occurrence of voids in the commercially pure material in a sense corresponds to the voids often observed during creep testing of impure material and consequently can probably be related to the chemical purity of the uranium. It would be interesting to see the work followed by a paper on the creep properties of uranium.

J. H. BECHTOLD



Courtesy Lukens Steel Co.

SAVE YOUR BASE METAL ... Descale with Sodium Hydride

The sodium hydride process for descaling stainless and alloy steels saves time, money and metal. It is much faster than pickling—15 seconds to 20 minutes instead of several hours. The process reacts with scale only, and does not attack the base metal. Pitting is eliminated and original dimensional accuracy is maintained.

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Division of National Distillers Products Corp.
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Machinability of Leaded Steels

Digest of "The Machinability of Type A Leaded Steels", by E. J. Paliwoda, \ominus Preprint No. 42, 1957.

MACHINABILITY indices of Type A leaded steels obtained from several production sources are reported. These, together with machinability indices of A.I.S.I. C 1213 steels are plotted against percent silicon content and percent carbon.

It is pointed out that mass of lead inclusions appears to be dependent on the nature of sulphide inclusions. Fine lead tails are associated with fine stringer-like sulphides.

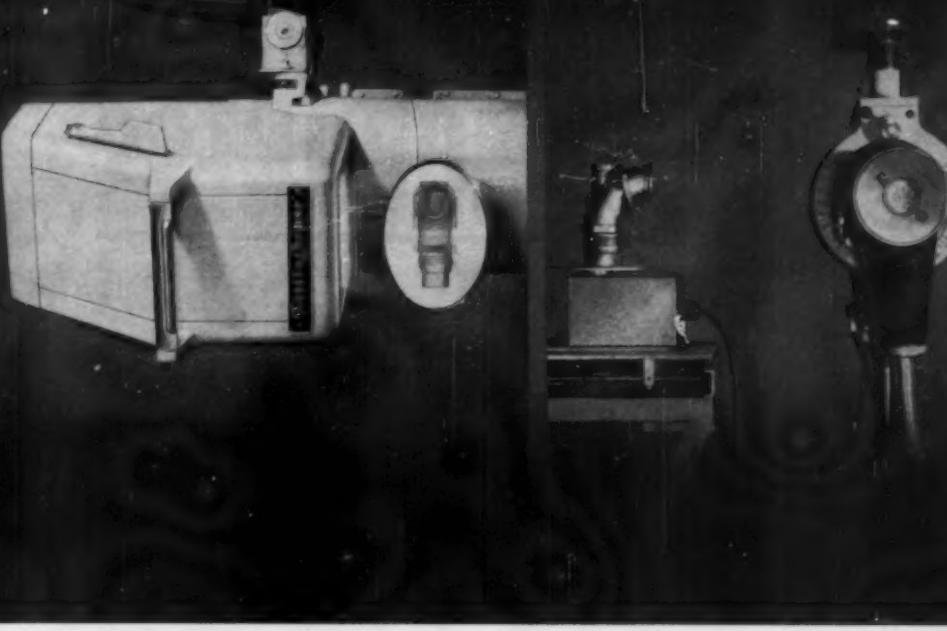
Tests were aimed at determining the highest turning speeds possible without exceeding prescribed wear of the cutting tool. This highest turning speed is reported as the machinability index.

The microdispersion of the lead in the steel was investigated, and illustrated by microradiographs. It is interesting to note that virtually all of the visible lead or lead compound particles are associated with sulphide inclusions.

Since shape formation and surface finish were not measured, the effect of phosphorus and nitrogen on machinability index was not measured in these tests.

Chemical composition variations in carbon, lead, sulphur, silicon and manganese affect the machinability
(Continued on p. 200)

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For whatever you make, from tractors to pressure cylinders, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products.



This bowl bottom assembly of the Caterpillar No. 470 Scraper requires numerous individual welding operations in its manufacture. Not only the parent metal, but the welds themselves, must have strength with toughness. Again, N-A-X FINEGRAIN steel proves its excellent weldability.



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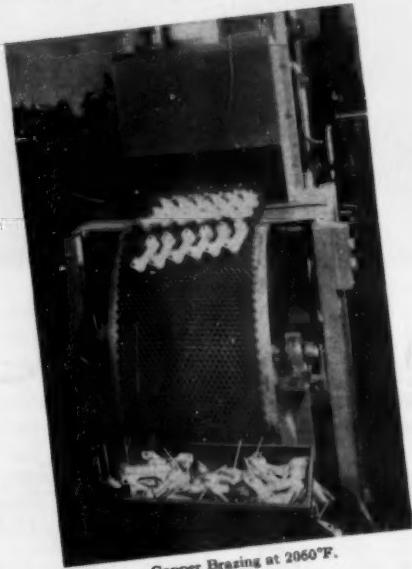
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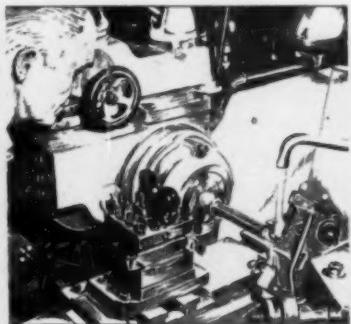


Leaded Steels . . .

of the leaded high-sulphur steel in a fashion parallel to the effect of these elements in regular screw stock.

As carbon content decreases, machinability increases in both leaded and C 1213 steel: A 0.01% decrease in carbon adds 6 index points to the machinability of Type A leaded steel, and a 0.01% decrease in carbon adds 8½ index points to the machinability of C 1213 steel.

As lead and sulphur contents increase, machinability increases: A 0.01% increase in lead adds 1 index point to the machinability of Type A leaded steels; a 0.01% increase in sulphur in regular openhearth steel



adds 1½ points to the machinability index; a 0.01% increase in sulphur in leaded stock adds 1 index point to the machinability index.

As silicon increases machinability decreases in both steels: A 0.01% decrease in silicon adds 13 points to the machinability index of the leaded steels, and a 0.01% decrease in silicon adds 18 points to the machinability index of C 1213.

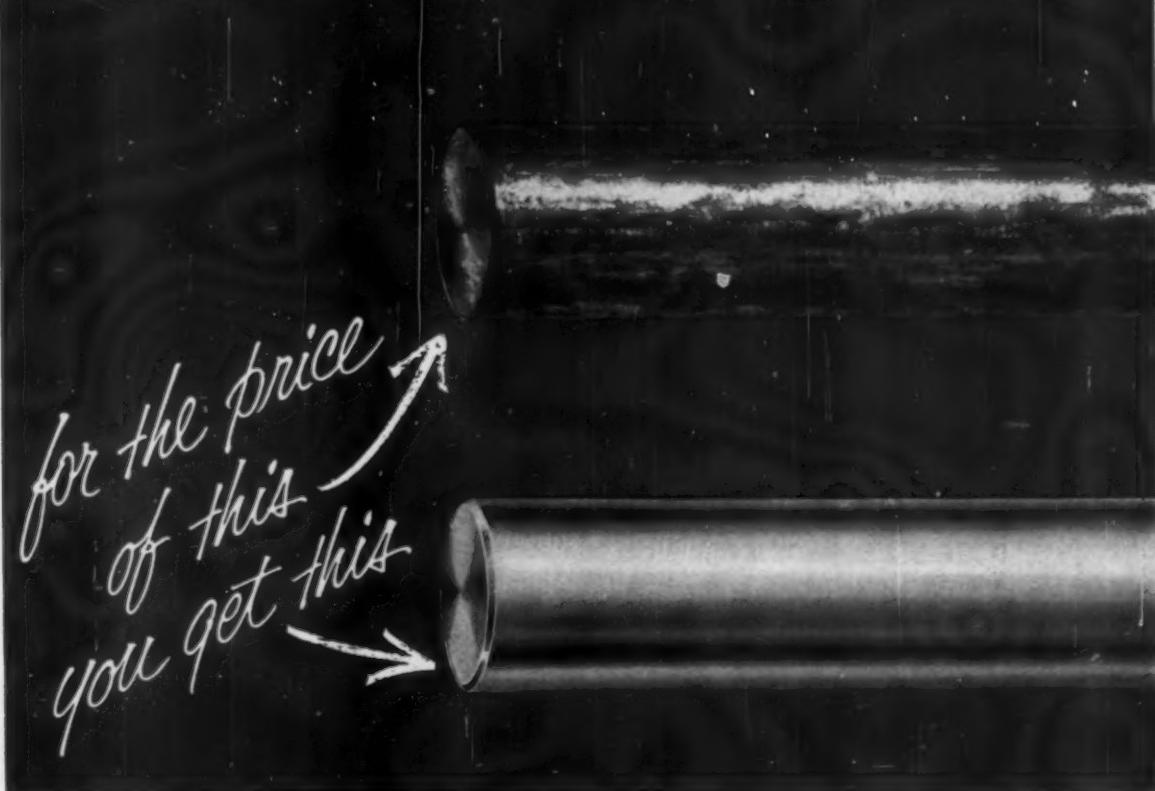
As manganese decreases, a slight increase in machinability is reported. (It has been the reviewer's experience that some manganese improves machinability from the chip formation standpoint but quite probably would be disadvantageous under the present test.)

Since chip formation and surface finish were not measured the effect of phosphorus and nitrogen was not measured in these tests.

In tests reported, the relationship of chemical composition variations to machinability index is expressed as: Machinability index = 265 - 600 (% C) - 1300 (% Si) - 100 (% Mn) + 100 (% S) + 100 (% Pb).

E. J. WELLER

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Hardness of Zirconium-Uranium Alloys up to 1650° F.

Digest of "A Hot-Hardness Survey of the Zirconium-Uranium System," by W. Chubb, G. T. Muehlenkamp and A. D. Schwope, Preprint No. 2, 1957.

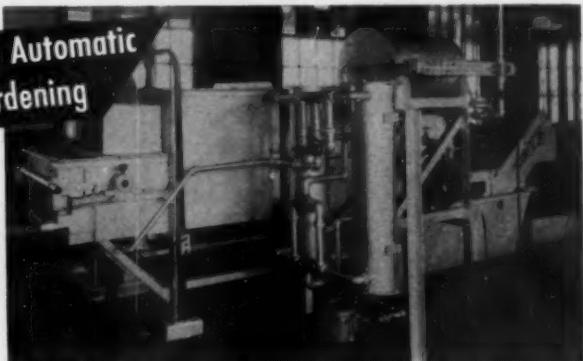
THE USE of zirconium as a structural material in nuclear reactors, and particularly as an alloying element or a cladding material for the uranium fuel, has prompted a survey of the mechanical properties of zirconium-uranium alloys. Hardness measurement was chosen because of its simplicity compared with other test methods. Hardness measurements at elevated temperatures may be of particular value (a) in indicating the maximum useful temperature for an alloy, and (b) in acting as a guide for fabrication practices such as hot rolling and forging. The principal limitation of hardness as a property is that it provides relatively

little information about ductility.

Hot hardness measurements were made in an apparatus capable of handling specimens at temperatures up to 1000° C. (1830° F.) and in a vacuum of less than 5 μ Hg. The specimen was raised against a sapphire-tipped column that the specimen lifted and supported for approximately 10 sec. The column weighed 1 kg. and the sapphire tip had the Vickers pyramid shape; all hardness values were reported as diamond pyramid hardness numbers.

The hardness survey was conducted on the pure metals and on 11 alloys, spaced approximately at equal intervals in atomic per cent across the phase diagram. Alloys were prepared by arc melting or by induction melting, with no hardness trends being attributed to these differences in preparation. All alloys were hot rolled to $\frac{1}{8}$ -in. sheet in the gamma range at temperatures between 700 and 930° C. (1290 and 1705° F.). Prior to testing, they were heated for 24 hr. at 575° C. (1065° F.). Hardnesses were determined at room temperature, 300,

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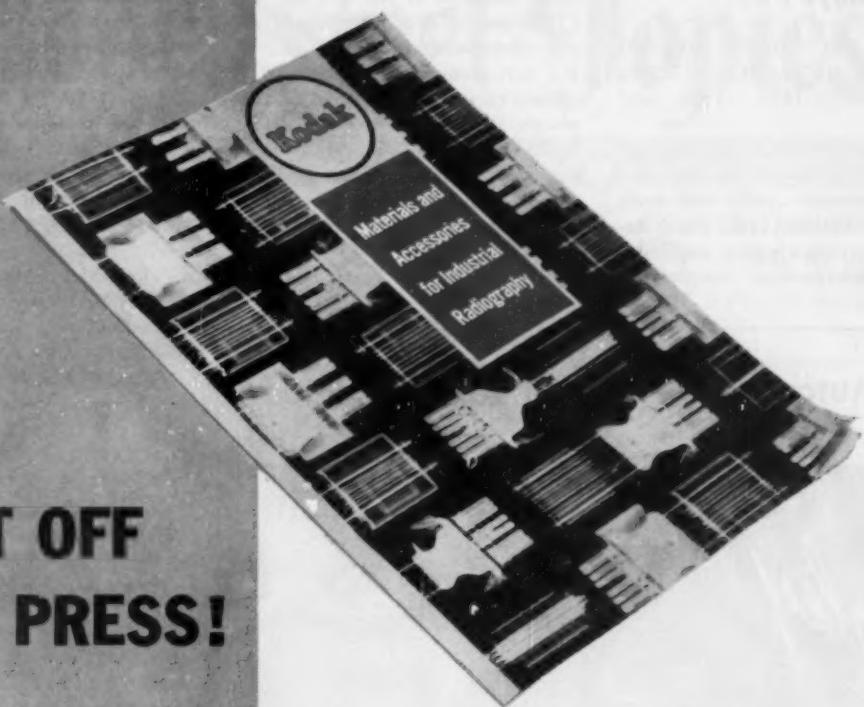


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Zr-U Alloys . . .

500, 600, 650, 700, 750, 800, 850 and 900° C. (570, 930, 1110, 1200, 1290, 1380, 1470, 1560 and 1650° F.).

At all temperatures, the hardness tended to be lowest for the pure metals, increased rapidly with small alloying additions, and then increased more slowly to a maximum at some intermediate composition.

Notable exceptions to this generalization occurred at 700 and 800° C. (1290 and 1470° F.) for zirconium-rich alloys and at 700° C. (1290° F.) for uranium-rich alloys. Zirconium-rich alloys consisted of two phases at 700 and 800° C. (1290 and 1470° F.), and the presence of increasing amounts of the soft gamma solid solution phase with added uranium resulted in an initial hardness decrease. The gamma phase itself became harder with in-

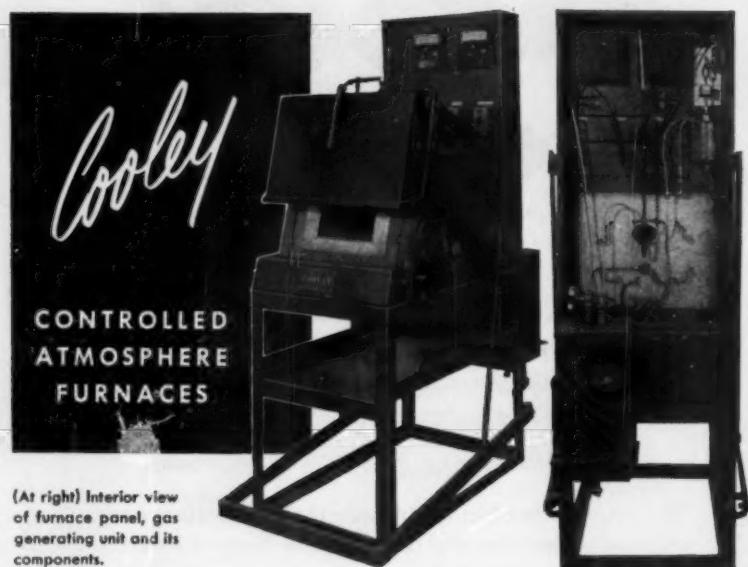
creasing uranium content and it eventually passed through a maximum in hardness midway in the composition range. Uranium-rich alloys up to about 5 at.% zirconium at 700° C. (1290° F.), contained the hard beta uranium structure, which was far the hardest of all the zirconium-uranium alloys in the temperature range of 650 to 760° C. (1200 to 1400° F.). Alloys containing beta uranium undoubtedly are more difficult to work than other alloys in this system.

The maximum hardness at room temperature was at about 60 at.% uranium (80% by weight). With increasing temperature up to 600° C. (1110° F.) this maximum shifted to about 30 at.% (50% by weight). From 500 to 600° C. (930 to 1110° F.) it corresponded to the approximate composition range of the delta phase reported by Holden and Seymour (*Transactions, A.I.M.E.*, Vol. 206, 1956, p. 1312).

As the gamma phase began to appear at temperatures of 600° C. (1110° F.) and above, all alloys decreased rapidly in hardness. Typical hardness numbers for a 50 at.% alloy were 360 D.P.H. at room temperature, gradually decreasing to 230 D.P.H. at 500° C. (930° F.), sharply dropping to 74 D.P.H. at 600° C. (1110° F.) and then 15 at 650° C. (1200° F.), after which the hardness gradually decreases to 8 at 900° C. (1650° F.).

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Quench-Aging Behavior of Ferrite Containing Carbon and Nitrogen

Digest of "Morphological and Phase Changes During Quench-Aging of Ferrite Containing Carbon and Nitrogen", by G. Lagerberg and B. S. Lement, *Preprint No. 33, 1957*.

THE ALLOYS used in this investigation were of high purity in the following compositions: Fe-C (0.016% C), Fe-N (0.084% N), and two Fe-C-N alloys (0.021% C, 0.028% N, and 0.023% C, 0.011% N respectively). Their quench-aging behavior was studied by light metallography, electron diffraction and electron metallography.

Experimental carburizing, decar-



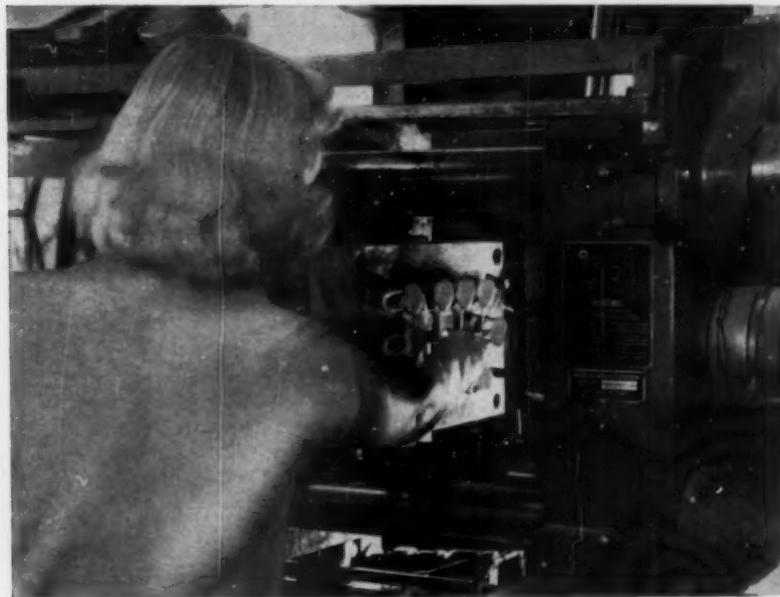
Tool Steel Topics

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Lustre-Die Takes High Polish For Molding Plastic Rattles

Shreve Molded Products, Youngstown, Ohio, needed an injection mold for the production of heart-shaped parts for baby rattles, using acetate and styrene plastics. They wanted a mold capable of taking a high polish, so as to produce unusually attractive parts. In addition, the mold had to have the stamina to perform economically during long production runs.

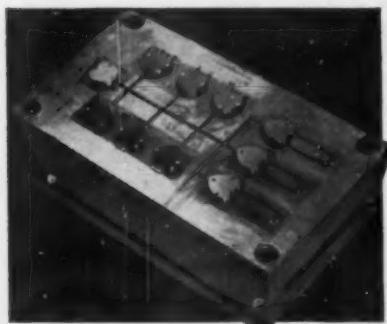
The problem was put up to Leed Steel Co., Buffalo, N. Y., Bethlehem's local tool

steel distributor. Their recommendation was Lustre-Die tool steel. It proved to be an excellent choice, too, for the mold, which was produced by Tri-Penn Tool Co., Erie, Pa., has been satisfactory in every way.

Lustre-Die is ideal tool steel for producing plastic parts because its properties enable it to take an unbelievably bright, mirror-like polish. Not only does Lustre-Die have the proper basic analysis for working with plastics—we even go a step beyond that by adding alloy fortification. We also build up the steel's excellent properties by oil-quenching and tempering, so that it can be furnished ready for machining and polishing.

Lustre-Die is made in the electric furnace, and is carefully inspected to insure cleanliness. It has a minimum of inclusion-causing additions. Besides, modern inspection methods hold injurious porosity to the minimum.

If you have any questions about Lustre-Die, or if you would like to give it a trial run, your Bethlehem tool steel distributor will be pleased to assist you.



BETHLEHEM TOOL STEEL ENGINEER SAYS:

It Pays to Keep Tools Sharp

In many shops, resharpening of production cutting tools is sadly neglected. In an effort to keep output high, too many tools are kept in use beyond the point where the cutting edges become excessively dull.

What happens when edges are dull? The dull edges cause an increase in the service load of the shearing or cutting operation. If the dullness is carried to extremes, tools break. Dull edges also produce rough surfaces on the parts, which may lead to rejections due to defects, or because the permissible tolerances have been exceeded.

Should resharpening be delayed too long, it may be impossible to recondition a tool properly, as deep spalls, cracks and gouges cannot be removed. Usually there is an economic balance point where it is best to resharpen, and for each operation this should be determined in advance. Tools should also be inspected regularly, to prevent excessive dulling. Intelligent use of preventive maintenance of cutting edges can work wonders in providing longer tool life and fewer broken tools.



Bearcat Puts Square Holes in $\frac{1}{2}$ -in. Plate

In this operation, photographed at Frink Sno-Plows, Inc., Clayton, N. Y., Bethlehem Beareat is putting $11/16$ -in. square holes in carbon-steel plate, used as cutting edge of snow plows. Though the steel plate is $1/2$ in. thick, the average life of each punch is 5500 holes.

Quench-Aging . . .

burizing and nitriding treatments were performed on $\frac{1}{8} \times \frac{1}{4}$ -in. bars, and on $\frac{1}{4}$ -in. diameter rounds of various lengths. The bars were annealed for 20 min. at 860°C . (1580°F .) in Vycor tubes to obtain uniform grain size. The carburizing treatment consisted of a 24-hr. cycle at 675 to 710°C . (1250 to 1310°F .) in hydrogen saturated (at

room temperature) with normal heptane. Nitriding treatment was 48 hr. at 580°C . (1075°F .) in ammonia-hydrogen mixtures. About $1/64$ -in. was machined from the surfaces of carburized samples to remove cementite layers.

The Fe-C-N alloys prepared by alternately nitriding and carburizing, used successively shorter treatment times. The final treatment was carburizing. All samples were homogenized. Carburized samples were

homogenized for 20 hr. at 720°C . (1330°F .) in Vycor tubes, and nitrided samples were heated 24 hr. in nitrogen at 580°C . (1075°F .). The ternary samples were held at 710°C . (1310°F .) in nitrogen for 24 hr. All solution treatment was done in nitrogen for 15 min. at 715°C . (1320°F .). Samples were then quenched in 10% aqueous sodium hydroxide at about 0°C . (32°F .). Aging treatments were performed in oil or salt baths at 90 to 472°C . (195 to 880°F).

Metallographic preparation of the specimens began with electrolytic polishing using 19 parts glacial acetic acid to one part perchloric acid. Current densities were 1 amp. per sq. cm. and polishing times 20 to 30 sec. Specimens examined with the light microscope were etched with 1% Nital and then viewed under slightly oblique illumination.

Replicas for electron metallography were dry stripped from etched specimens. They were then rotary shadowed in vacuum, using chromium. The shadowing angle was about 27° .

Reflection electron diffraction measurements were also made on polished and etched surfaces, substituting a diffraction lens for the projector lens of the electron microscope. The electron beam was reflected off the specimen surfaces at a very low incident angle. This allowed protruding particles such as nitrides and carbides to give more intense diffraction patterns than the matrix. The voltage employed was 60 kv., corresponding to a wave length of 0.049° .

The authors came to the following conclusions:

1. The initial stage of aging at relatively low temperatures consisted of the formation of apparent films of various thicknesses at sub-boundaries in the ferritic matrix, indicative of a subgrain size of 10^{-4} to 10^{-5} cm. On continued aging, these apparent films were supplanted by platelets of a metastable phase. No comment was made as to the composition of the apparent films.

2. Depending on the type of supersaturation of the ferrite, the stages of aging were:

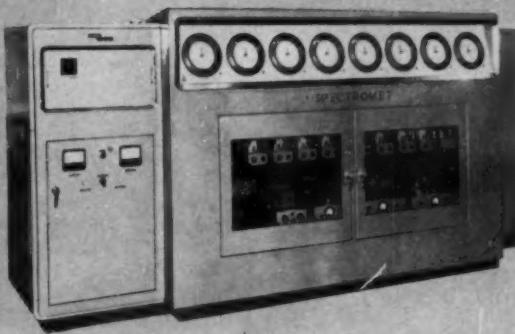
Ferrite supersaturated with carbon \rightarrow ϵ -carbide \rightarrow cementite.

Ferrite supersaturated with nitrogen \rightarrow α'' -nitride \rightarrow γ' nitride.

(Continued on p. 208)

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Quench-Aging . . .

Ferrite supersaturated with both carbon and nitrogen → ϵ -carbonitride → cementite.

At relatively high aging temperatures some evidence of direct formation of the stable precipitate was obtained.

3. In the Fe-C alloy, the transformation of ϵ -carbide to cementite oc-

curred after virtually all the carbon had precipitated from the supersaturated ferrite solution.

4. The ϵ -phase that formed in the Fe-C-N alloys was more stable than that formed in the Fe-C alloy. This was explained by the increased nitrogen content.

5. In Fe-C-N alloys the presence of nitrogen apparently promoted the formation of relatively large plates of cementite constituents.

S. T. Ross

High-Temperature Hardness Tester

Digest of "Apparatus for Determining the Hardness of Metals at Temperatures up to 3000° F.", by M. Semchyshen and C. S. Torgerson, \ominus Preprint No. 12, 1957.

A RELATIVE EVALUATION of the strength of metals and alloys at high temperatures may be obtained by comparing their hardnesses at temperature. A simple apparatus for impressing microhardness indentures in metals at temperatures up to 3000°F. and in an inert atmosphere is described. The test specimens are $3/16$ to $\frac{1}{8}$ in. thick and $\frac{1}{4}$ to 2 in. in diameter, but the size may be modified with the use of suitable fixtures.

The authors have made as many as 40 indentures on two small pieces held in one fixture. The indentor is a synthetic sapphire mounted in a molybdenum rod and dead-weight loaded from the exterior of the furnace through a water-cooled bearing. Multiple indentures are made possible by the rotation of the anvil whose axis is parallel but laterally displaced from the indentor axis.

The data obtained by the authors using this apparatus were sufficiently sensitive to indicate the change in hardness which occurs when iron transforms from alpha to gamma.

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Growing Cadmium Crystals From Vapor

Digest of "Growth of Cadmium From the Vapor", by J. E. McNutt and R. F. Mehl, \ominus Preprint No. 6, 1957.

OF the varieties of methods available for growing metal crystals, one of the simplest—growth from the vapor phase—was selected by the authors for study. High-purity cadmium was the metal used.

Experiments were carried out in a totally enclosed system, the reservoir of cadmium being heated with an external tin bath, and the vapor condensed on a Kovar surface by differential cooling with a gas stream.

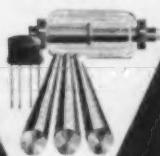
Transverse growth was accurately measured with an optical fiducial system, while changes in height were

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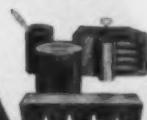
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NOVEMBER 1957

Crystal Growth . . .

followed by interferometric techniques with a sensitivity of 300 Å.

Thirteen experiments are reported, encompassing metal deposition over a thermal range of 288 to 356°C. (550 to 673°F.), the vapor pressures varying from 0.026 to 0.35 mm. Hg.

The cadmium crystals grew by step formation of basal planes, with hexagonal symmetry. "Ridge boun-

daries", defined as discrete, straight boundaries across a crystal separating two regions of slightly differing orientation, were noted. This type of region often served as the high energy point of nucleation for successive step growths.

There was no evidence of ridge boundary movement, nor of rational crystallographic directions.

Contrary to classical theory, new monolayers did not generally nucleate on the base crystal away from

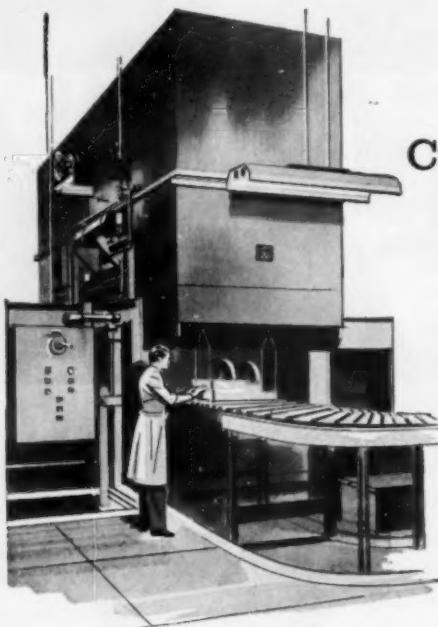
the edges. On the majority observed, steps appeared first at edges of basal surfaces where adjacent crystals touched. There was no periodicity or height consistency in new step formation—again contrary to expectations.

Propagation of steps occurred in many modes: continuous growth of large steps; extension growths of small steps; splitting into smaller steps with variant growth characteristics; and formation of sloped growth fronts. An interesting phenomenon was observed when a sloping growth front issuing from steps moved across a surface. They appeared to encounter points over which they could not move, causing a "wake" as the front moved past. The apex of the "wake" always pointed into the moving front, and the edges of the "wake" made crystallographically accurate 60° angles with the crystal sides. No explanation of this phenomenon is presented.

Data pertaining to rates of deposition and crystallographic directions are included. There is no evidence that any growth resulted from screw dislocations.

J. L. WYATT

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Dimensional Stability of Wrought Uranium

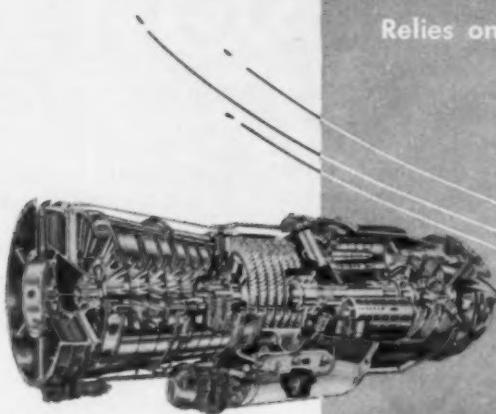
Digest of "Effects of Fabrication and Heat Treatment Variables Upon the Thermal Cycling Behaviour of Uranium", by S. T. Zegler, R. M. Mayfield and M. H. Mueller, *ORNL Preprint No. 56, 1957.*

THE DIMENSIONAL instability of wrought uranium under thermal cycling and irradiation has presented a difficult problem in the design and operation of solid fuel reactors. Information on the mechanism responsible for the dimensional changes and methods for minimizing or preventing them is now declassified.

The present paper is concerned chiefly with the effects of a number of fabrication variables including rolling temperatures, reductions and pass sequences and heat treating factors. It is based on work conducted at the Argonne National Laboratory.

The influence of rolling temperature on thermal cycling was insignificant below the recrystallization temperature, but this variable had important effects when high alpha-

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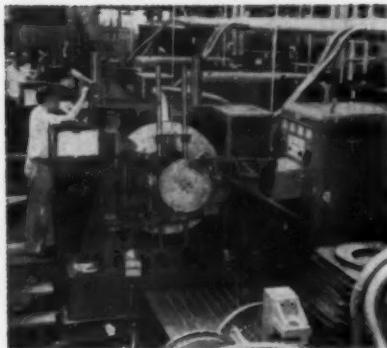


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*The ML-5668 electron tube was designed by Machlett specifically for heavy duty industrial applications.

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Wrought Uranium . . .

phase temperatures were attained in the heating cycles. Rolling temperatures of 800° C. (1110° F.) and 640° C. (1185° F.), which are well above the recrystallization temperature, afforded substantially less growth than was observed after rolling at lower temperatures such as 300° C. (570° F.).

Improved performance of metal rolled at the lower temperatures was also obtained by subsequent annealing at temperatures producing recrystallization and grain growth. On the other hand, the dimensional instability was aggravated by increas-

ing reduction and the resultant accentuation of rolling texture. These observations appeared consistent with the conclusion that the amount of growth increases with the degree of preferred orientation and with decreasing grain size.

Heat treating in the beta range for sufficient time to completely transform the material was found to reduce growth substantially. The behavior of the beta-treated uranium was dependent on the conditions of thermal cycling, varying from slight growth to slight shrinkage with changes in heating rate. The degree of surface wrinkling appeared related to the alpha grain size.

H. Y. HUNICKER

Yield Point in Mild Steel at Low Temperatures

Digest of "Some Aspects of Preyield Phenomena in Mild Steel at Low Temperatures", by W. S. Owen, M. Cohen and B. L. Averbach, *Preprint No. 9, 1957.*

FEW METALLURGICAL phenomena have been the subject of more research over a longer period of time than the yield point phenomenon in mild steel. Like many other metallurgical phenomena the yield point in mild steel seems to become more complex as we learn more about it.

The authors studied the sequence of events that occur before gross or discontinuous yielding takes place at room temperature and -196° C. (-320° F.). If a specimen of mild steel is loaded to a constant stress somewhat below the upper yield point and the nonelastic strain measured as a function of time, three distinct stages can be observed in the yielding process. First, a "micro-strain" stage in which the strain increases rapidly with time but levels off at a constant value of not more than 50×10^{-6} . Second, a "micro-creep" stage in which the strain is time dependent and precedes gross yielding. Third, a "Luder's strain" stage which is usually taken as the beginning of gross, discontinuous yielding.

In order to study these various stages of yielding, the authors used both constant-load strain-time tests—in a way low-temperature creep tests—and standard tensile tests in which the specimens were rapidly loaded to a predetermined load, held for a constant time and then unloaded. From these tests they determined the elastic limit, or the stress at which microstrain begins; the amount of microstrain; the stress at which the "micro-creep" rate is 10^{-6} per min.; the amount of "micro-creep"; and the yield strength above which a marked increase in plastic strain rate and "Luder's bands" occurs. These various stages were studied as a function of ferrite grain size, austenitizing temperature and in two steel compositions.

At -196° C. (-320° F.) the various stages of yielding are much more evident than at room temperature, particularly the micro-creep stage which is almost unobservable



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Yield Point . . .

at room temperature but is appreciable at -196°C . (-320°F). The elastic limit and yield strength are also much higher at -196°C . than at room temperature and the stress separation between the various yield criteria is much greater. At both temperatures the elastic limit and the yield strength increase with decreased ferrite grain size, approximately as the reciprocal of square root of the grain diameter, although there is some deviation in this rule for large grain sizes. The micro-strain and the micro-creep are af-

fected very little by grain size but depend rather strongly on austenitizing temperature, cooling rate and steel chemistry.

The authors discuss their results in a qualitative way in terms of the Clark-Wood dislocation model for yielding which is very similar in many details to the Stroh-Petch model of brittle fracture. In both models dislocation groups are visualized as piling up at grain boundaries, or other barriers, until the local stresses are built up sufficiently to cause yield (Clark-Wood) or a micro-crack (Stroh-Petch) in the adjoining grain and cause either gross yielding or fracture. The data in

general agree with the Clark-Wood model except for the large amounts of micro-creep observed at low temperatures, which is not readily predicted. However, it would probably require only a minor modification of the theory to account for the appreciable micro-creep.

In one of the very interesting tests mentioned, fracture occurred during, or subsequent to, micro yielding below the static yield point. This was not discussed. It would be very interesting to see additional delay time studies on fracture. In a recent paper E. T. Wessel observed pre-yielding as a function of temperature and found a distinct maximum in the pre-yield strain. He postulates that there is a temperature below which piled-up dislocation groups initiate microcracks as well as gross yielding and above which only yielding occurs. Unfortunately the authors of the present paper studied delayed yielding only at -196°C . (-320°F) and room temperature. It would be extremely interesting to see results of similar tests at intermediate temperatures.

The yield phenomenon in mild steel is certainly complex and simple theories such as the widely accepted Cottrell-Bilby cannot be correct in detail. From work such as this, however, a better understanding of the phenomenon is being obtained.

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New Uses for Carburized Steels

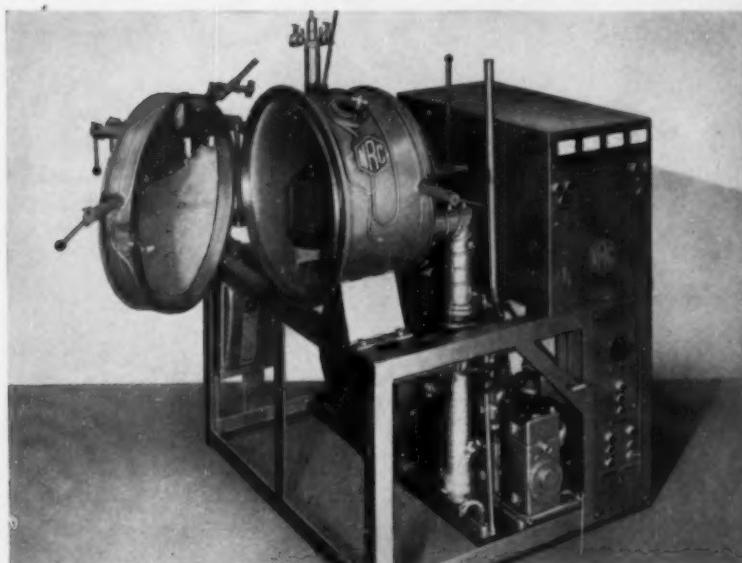
Review of "Fatigue Durability of Carburized Steel", by seven authorities. 123 pages. Published August 1957 by American Society for Metals.

As a result of the growth in use of mild steels with carburized surfaces during recent years, we have, in effect, access to a new group of engineering materials. As is often the situation with new materials, there is a need for data to govern applications of these materials. As to carburized steels, for example, comparatively little is known about their fatigue characteristics and the interrelationship of several factors having an important effect on fatigue properties.

Some new light on the subject is
(Continued on p. 218)

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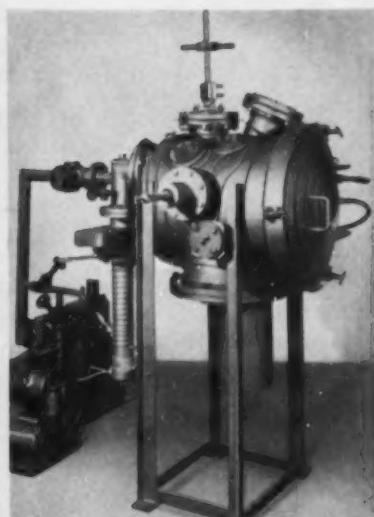
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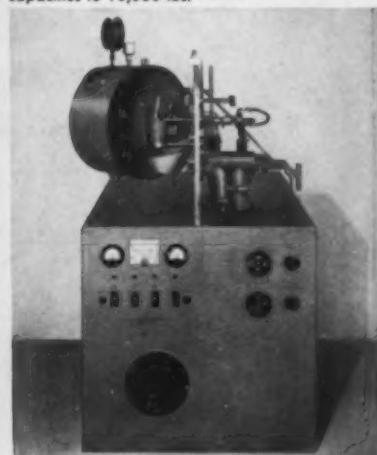
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IN THIS



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The Production of Metals... In the steel mill, the smelter, the large forge shop, technical management has increased sharply since 1940, is only now on the verge of further tremendous expansion of influence. Metals engineers have the knowledge to put the muscle in the metal. They control and determine melting, heating, and forming operations through the constant use of ME Factors. Metal Progress is the only magazine to attract and deliver the men in the mill whose primary interest and influence is *on the metal*.

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METAL PROGRESS



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Carburized Steels . . .

provided by this book, based on a series of educational lectures prepared by seven members of the General Motors Corp. research staff for presentation at the 38th National Metal Congress. Experts in each of several areas outline the nature of their research, their test methods and their conclusions.

Although the book does not at-

tempt to serve as a complete manual for applications of steels of this type, it provides an effective guide to test methods for determining the suitability of carburized steels for potential applications.

Among the new investigations carried on by the book's authors are those concerning the effect of skin condition on durability, the effect of different types of carburizing atmospheres and the effect of residual stresses on durability. Each of these

is studied independently as well as in relationship to each other.

Among information developed by the authors is the knowledge that increases in fatigue life can be obtained by (a) electropolishing after carburizing, (b) minimizing surface oxidation and (c) using low-carbon carburizing steels.

T. H. DUMOND

Relationship of Carbide Precipitation to Brittleness in 18-8

Digest of "Carbide Precipitation and Brittleness in Austenitic Stainless Steels", by A. Kramer and W. M. Baldwin, Jr., Preprint No. 32, 1957.

AS A GENERAL CLASS, austenitic stainless steels show a decrease in ductility when the rate of straining is increased. Although the embrittlement is not marked (ductility decreases by 40% as measured by true strain at fracture), it could be of importance in drastic forming operations.

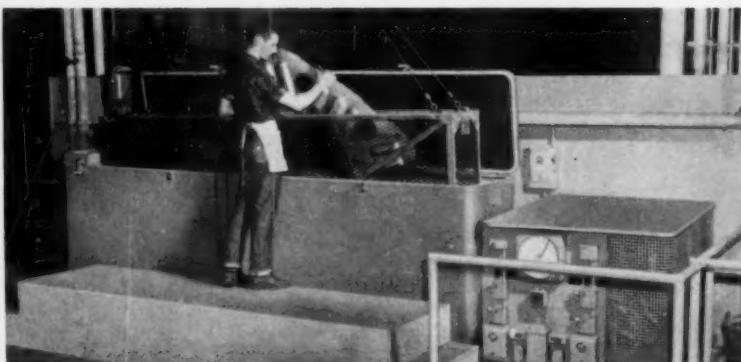
The authors studied several 18-8 stainless steels of different carbon levels (Types 302, 304, and 304 LC) in the fully annealed and the sensitized condition. Sensitization produced a tendency for embrittlement at low strain rates and low temperatures and had little effect on the drop in ductility at high rates of strain. The embrittlement caused by carbide precipitation was accompanied by intergranular fracture.

Magnetic measurements of the amount of martensite formed during deformation showed no correlation with ductility. This observation is in agreement with earlier results discounting martensite formation as a cause of the high strain rate embrittlement. Similar measurements on the sensitized materials indicate that differences in martensite content are not responsible for the low strain rate embrittlement either.

While offering no mechanism responsible for the embrittlement, this work eliminates two frequently suggested causes. In addition, the authors show that sensitization can lead to embrittlement at low temperatures and low strain rates. Clearly more study is required to understand these phenomena.

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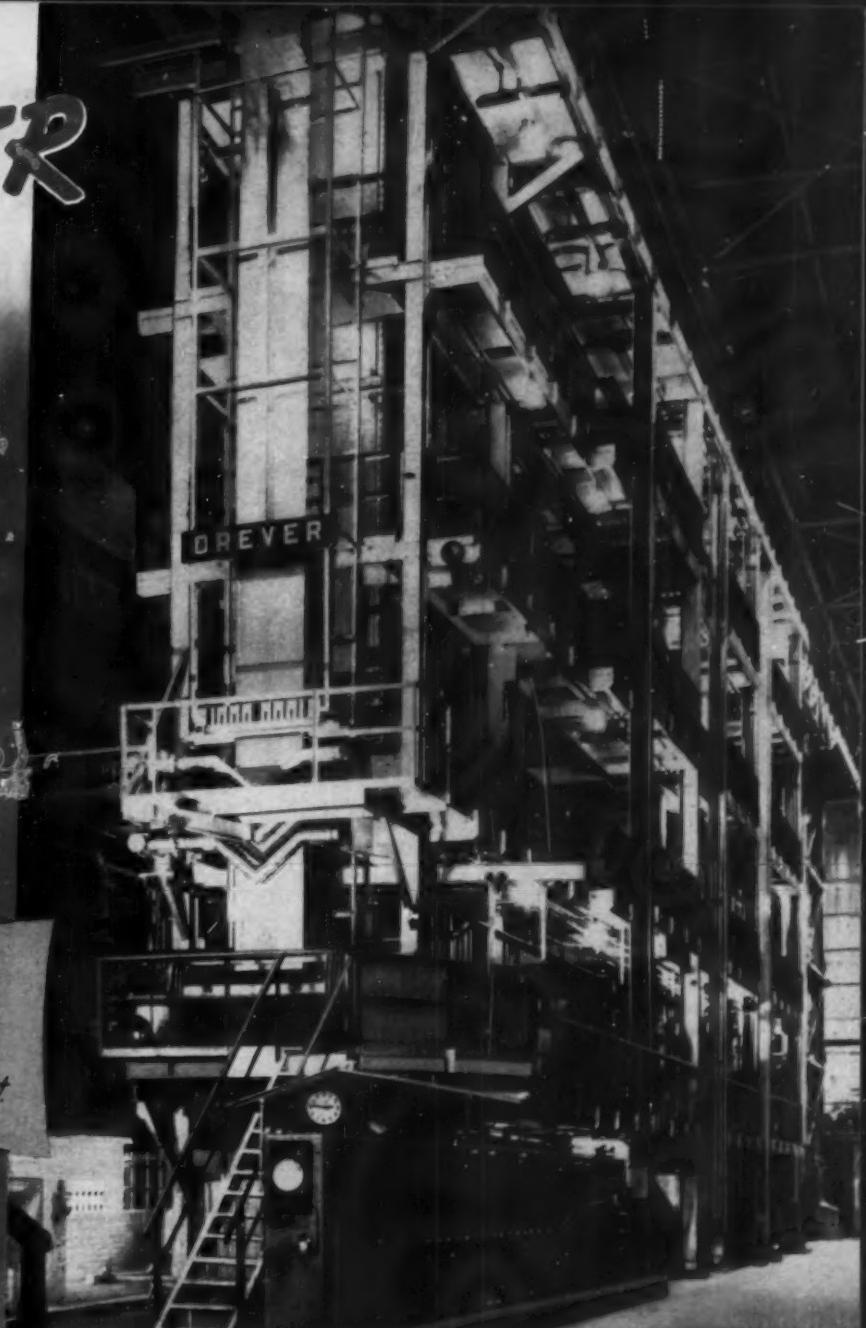
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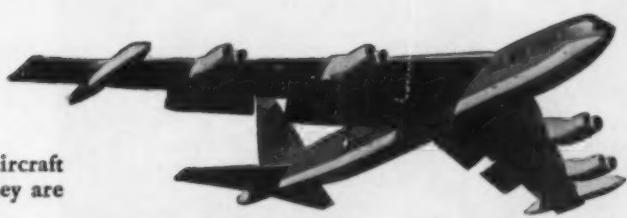
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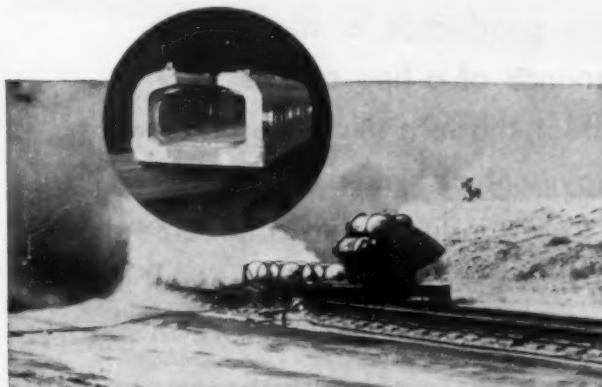
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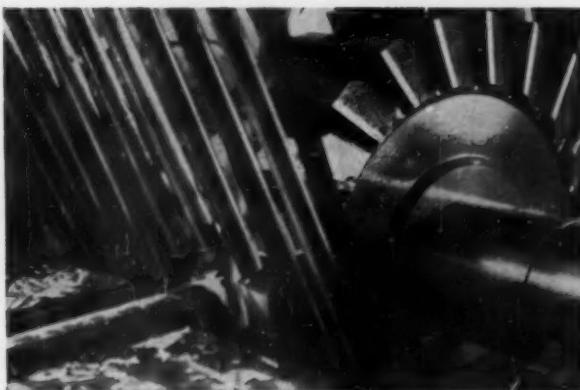
During steam treatment a tough, hard, porous oxide film . . . Fe_3O_4 . . . is formed on the tool surface. This micro-thin film, only 0.0001" thick, is tightly adherent, has a pleasing blue-black color, is sufficiently porous to retain cutting oil and has a high degree of corrosion resistance.

As a result, many drills, reamers, hobs, milling cutters, broaches, saws, and other tools hold their cutting edges 5% to 100% longer when steam treated after tempering and final grinding. This ratio goes up . . . often as high as 6 to 1 . . . for tools used to cut extra tough materials such as alloyed structural steels. It doesn't take much imagination to translate such extra tool-life into lower production costs through reduced set-up time, lower tool costs and less non-productive labor.

On the opposite page are just four examples to illustrate our point. If you want others . . . or details on any of these . . . or want us to help investigate possible savings you can make, just phone your nearest L&N office or write us at 4927 Stenton Ave., Phila. 44, Pa.

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Milling Cutters Do 500% More Work . . . When milling the ends of these Nichrome heater rods operators always averaged 25 cuts . . . then spent 20 to 30 minutes changing to a new cutter. In an effort to reduce such high job time, steam treated tools were made standard practice in this shop. The results: operators averaged 150 cuts before resharpening was necessary . . . 500% more use from each tool . . . 1½ hours less set-up time for every 150 pieces.



Chipping Rejects Are Eliminated . . . Drilling, reaming and boring these bakelite insulating blocks used to be an expensive job. Although the actual operation didn't take long, the abrasive action of the bakelite dulled tools so rapidly that cracking and chipping caused a prohibitively high number of rejects. The cost of the material and the large number of man-hours invested prior to the drilling operations made the problem even more acute.

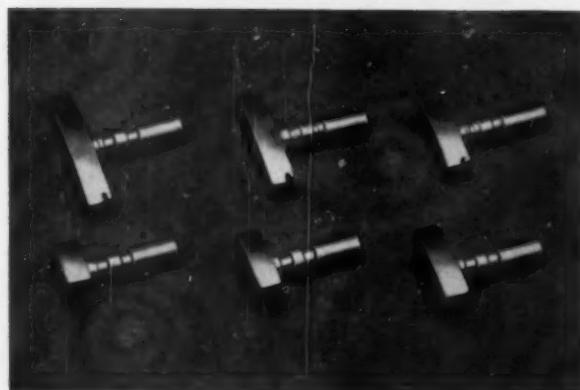
To break the bottleneck, steam treated tools were tried. Previously, one tool was good for about 10 holes, with an average reject rate of one out of four blocks. With steam treated tools, the average went up to 25 holes and rejects were no longer a critical factor.



Drill Maker Improves Product Quality . . . The manufacturer of these drills made extensive tests before adopting the steam Homo method as standard treatment for all milled flute regular and heavy duty drills. Here are comparative test results on a 37/64" H.S. drill cutting a 2" billet of S.A.E. 3240 chrome-nickel steel with a Brinell hardness of 248-255 at a speed of 345 RPM, feeding 52 FPM at .007"/rev.

Treatment	Drill No.	1st Test	2nd Test	3rd Test
None	1	33 holes	43 holes	38 holes dull
None	2	31 holes	43 holes	60 holes still cutting*
Steam treated	3	62 holes	64 holes	60 holes still cutting*
Steam treated	4	50 holes	69 holes	60 holes still cutting

*Drill #2 was steam treated before this test. Drill #3 was given an additional steam treatment before this test.



Pick-up From Soft Metal Eliminated . . . A production bottleneck was created when a batch of formed nickel stock, used to make these segments of multipoint switches, came through too soft. Pick-up on the form tool of the automatic screw machine kept ruining the parts.

When experiments with different tool steels and sharpening methods completely failed to solve the problem, a steam treated tool was tried. This one tool finished the entire run of 3000 pieces and was still in good condition. Production delays because of material variations are no longer a problem in this shop.

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NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the trademark for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite

is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished

part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.



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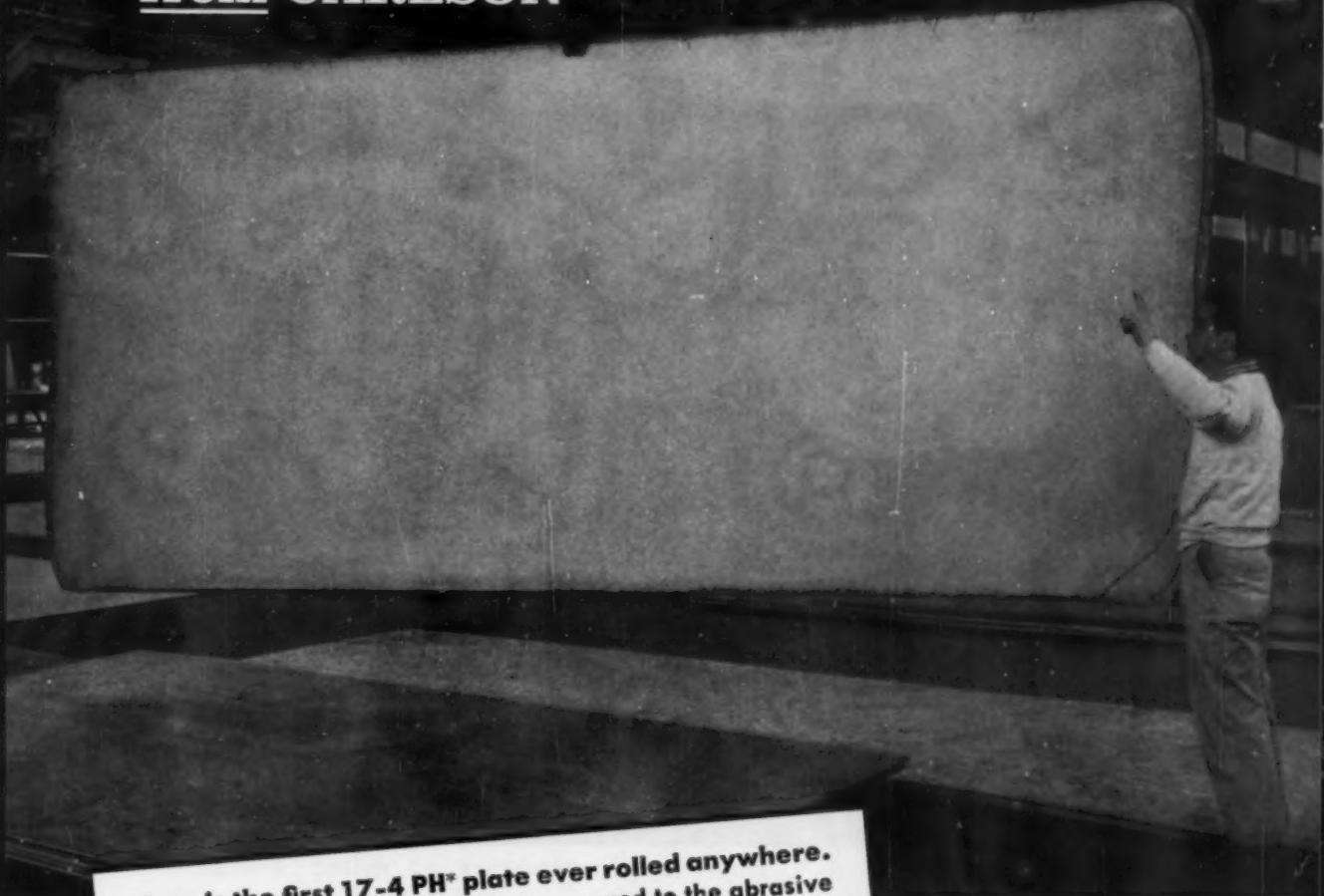
ALLOY ENGINEERING & CASTING COMPANY



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CHAMPAIGN, ILLINOIS

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This 179" x 79" x 1" plate is being moved to the abrasive
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You can build equipment with either of two precipitation-hardening stainless plate grades—17-4 PH* and 17-7 PH*. Both are available at Carlson—both can be cut to your exact specifications to save delays and true-up time in your own plant.

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MILLIONS OF SHARP, SUPERHEATED PARTICLES,
traveling at high velocities, quickly wear dust collector linings, mains, downcomers, etc. Metals and most ceramics simply can't withstand this harsh abrasion. But CARBOFRAX[®] refractories can—even at temperatures as high as 2500°F. A CARBOFRAX dust collector lining in an ore sintering machine is, for example, still in use after 10 years' service.

Refractories...to resist abrasion

Exceptional resistance to abrasion—whether caused by tiny gas-borne particles or sliding steel billets—is one of the most useful properties of several of Carborundum's unique refractory materials. For example, when used in the exhaust lines of gasoline catalytic cracking units in temperatures ranging up to 1200°F, these refractories lasted 3 years, as compared to alloy rings which lasted for 6 months.

And when abrasion is combined with higher temperature, the exceptional resistance of these super refractories becomes even more apparent and useful. As skid rails in furnaces which heat 6-lb. billets to 2250°F—pushing 250 slugs an hour—CARBOFRAX[®] silicon carbide refractories need one-third the replacement, one-third the labor and one-third the down-time of ordinary rammed chrome ore hearths. Other successful applications include: dust collectors, gas scrubbers, transfer pipe lines, hydro cyclones and process equipment parts, to name but a few.

Many applications call for other properties in combination with wear resistance. Among Carborundum's many materials are refractories that also offer excellent heat shock resistance

with sufficient hot strength to withstand 25 psi at 3128°F. Others provide unique resistance to corrosion as well as abrasion. These properties are but a few of those to be found in super refractories pioneered by Carborundum. Among them, you are almost certain to find answers to your refractory and high-temperature problems. For help, fill in and mail this coupon:

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Please send me:

- Forthcoming issue of Refractories Magazine
 Bulletin on Properties of Carborundum's Super Refractories
 Here is a description of my high temperature problem.
Can you help me?

Name _____ Title _____

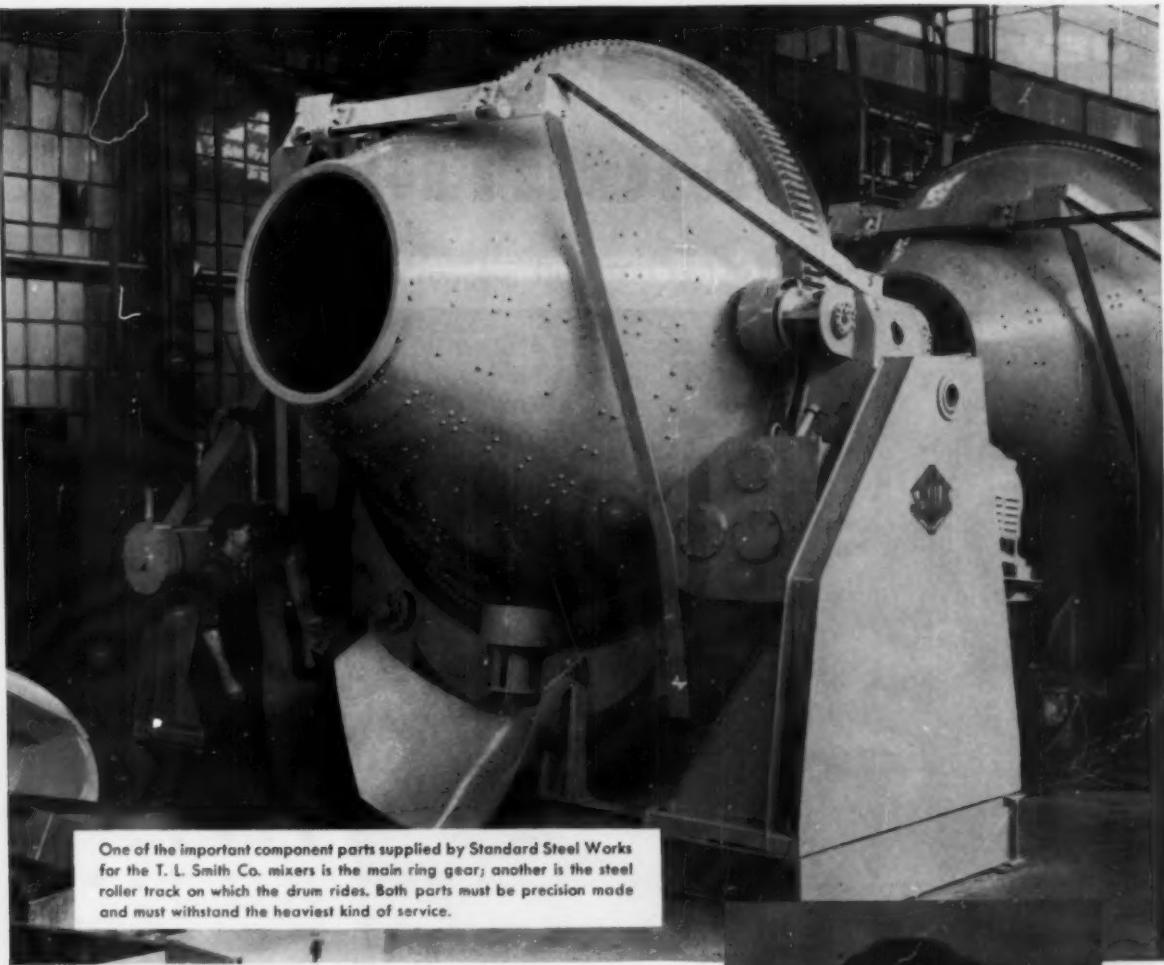
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One of the important component parts supplied by Standard Steel Works for the T. L. Smith Co. mixers is the main ring gear; another is the steel roller track on which the drum rides. Both parts must be precision made and must withstand the heaviest kind of service.

"The T. L. Smith Co. is constantly seeking design improvements and production economies. Standard Steel Works has proved a big help to us in both respects."

As suppliers of component parts to the T. L. Smith Co.—world's oldest and largest manufacturer of concrete mixers—we have made it *our* business to get to know *their* business well enough to consider ourselves a part of their team.

It is our policy to work in the closest possible cooperation with all of our customers to assure maximum quality at lowest possible cost. Let us discuss your casting and forging needs with you. You'll find that service to our customers is as important as the quality of the products we make. Write Dept. 3-L.



"We are particularly impressed with Standard's methods—people and the way their engineers so effectively supplement our own in constantly suggesting design improvements and production economies," says R. R. Kupfer, purchasing agent for the T. L. Smith Co., Milwaukee, Wis.

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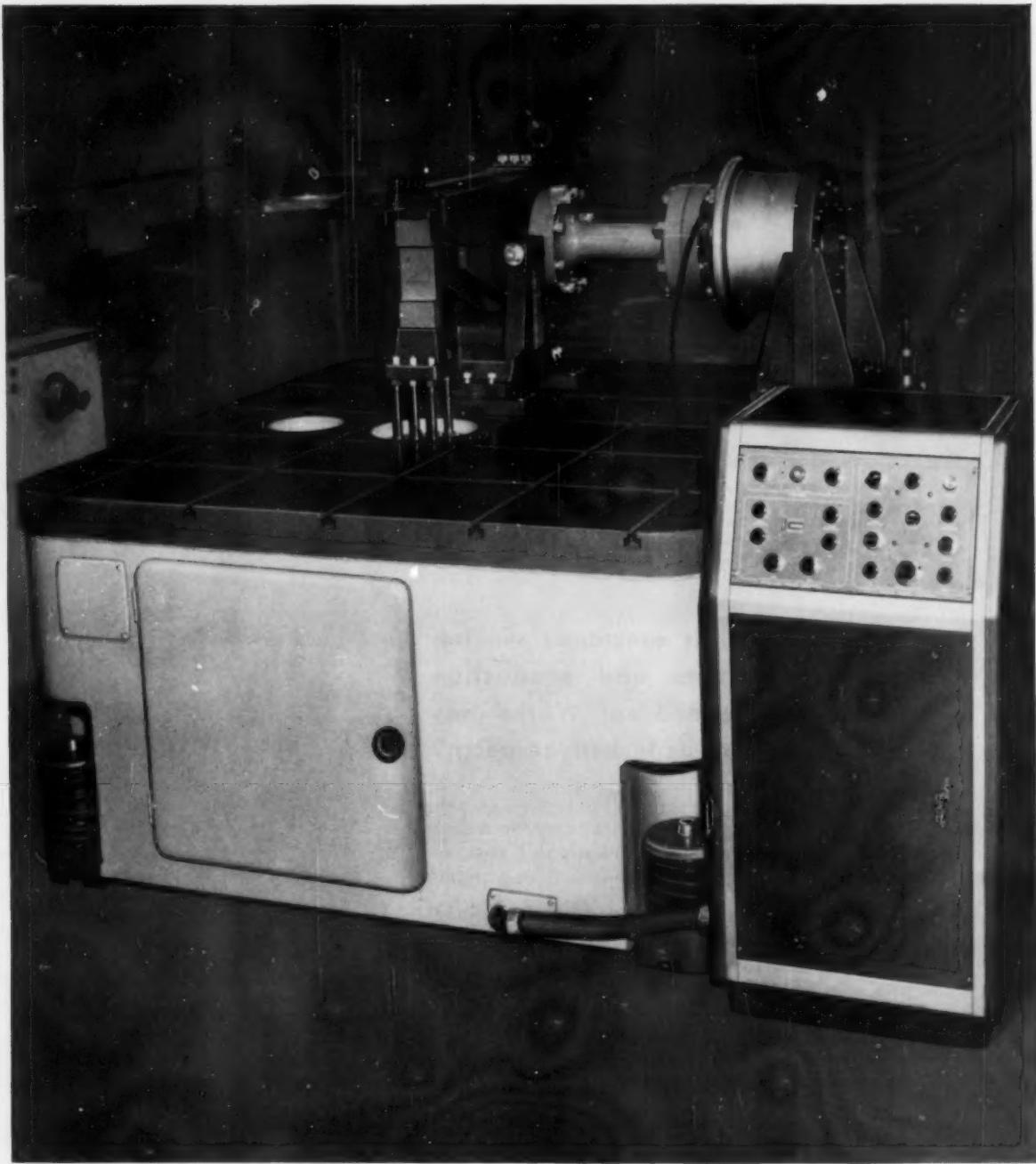
NOVEMBER 1957



NEWS FROM B-L-H

Introducing the

I-V MULTI-RANGE



Fixture mounted on Model I-V 20 is putting an aircraft brake assembly through a series of fatigue tests. Separate console locates electronic control equipment away from vibration.

new and complete line of FATIGUE TESTERS

In six sizes with capacities ranging from 200 to 120,000 lb. at the high load station and amplitudes up to $\pm \frac{3}{4}$ in. maximum at the high amplitude station

Now ready for delivery, the new B-L-H line of I-V multi-range fatigue testing machines meets an unusually broad variety of requirements. Whether for production testing of machine members, components and structural assemblies, or for testing research specimens, I-V Fatigue Testers offer you high accuracy, combined with maximum versatility and simplicity of operation. By use of suitable fixtures, the possible combinations of static and dynamic loads permit the simulation of almost any service condition.

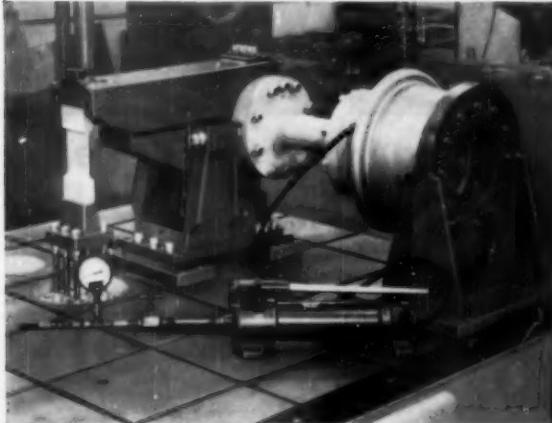
A 5 to 1 force-multiplying fixture can be added to all models. For example, it will increase the load capacity of Model I-V 120 from 120,000 to 600,000 lb.

A unique feature of the I-V Fatigue Tester is its multi-range design. This provides two loading stations, one for applying full force capacity and one

for high amplitude tests up to $\pm \frac{3}{4}$ in. maximum. Amplitude limits, automatically maintained while the machine is running, permit stopping of a test just before complete specimen separation to allow metallurgical examination of the region of crack initiation.

The three smaller models, I-V 02, I-V 1 and I-V 4, are available in operating frequencies of either 1200 or 1800 cpm; the larger models, I-V 20, I-V 50 and I-V 120, of only 1200 cpm.

For the best in testing, see B-L-H first. You can choose from the industry's most complete line of testing equipment, including tension, compression, creep, fatigue, impact or torsion. Let us send a B-L-H representative around to see you. Or call on us for detailed information.



Closeup of wheel-and-brake test fixture showing hydraulic pump used to apply brake pressure.



Model I-V 20H (with furnace and high temperature fixture). Special control panels record temperature and creep.

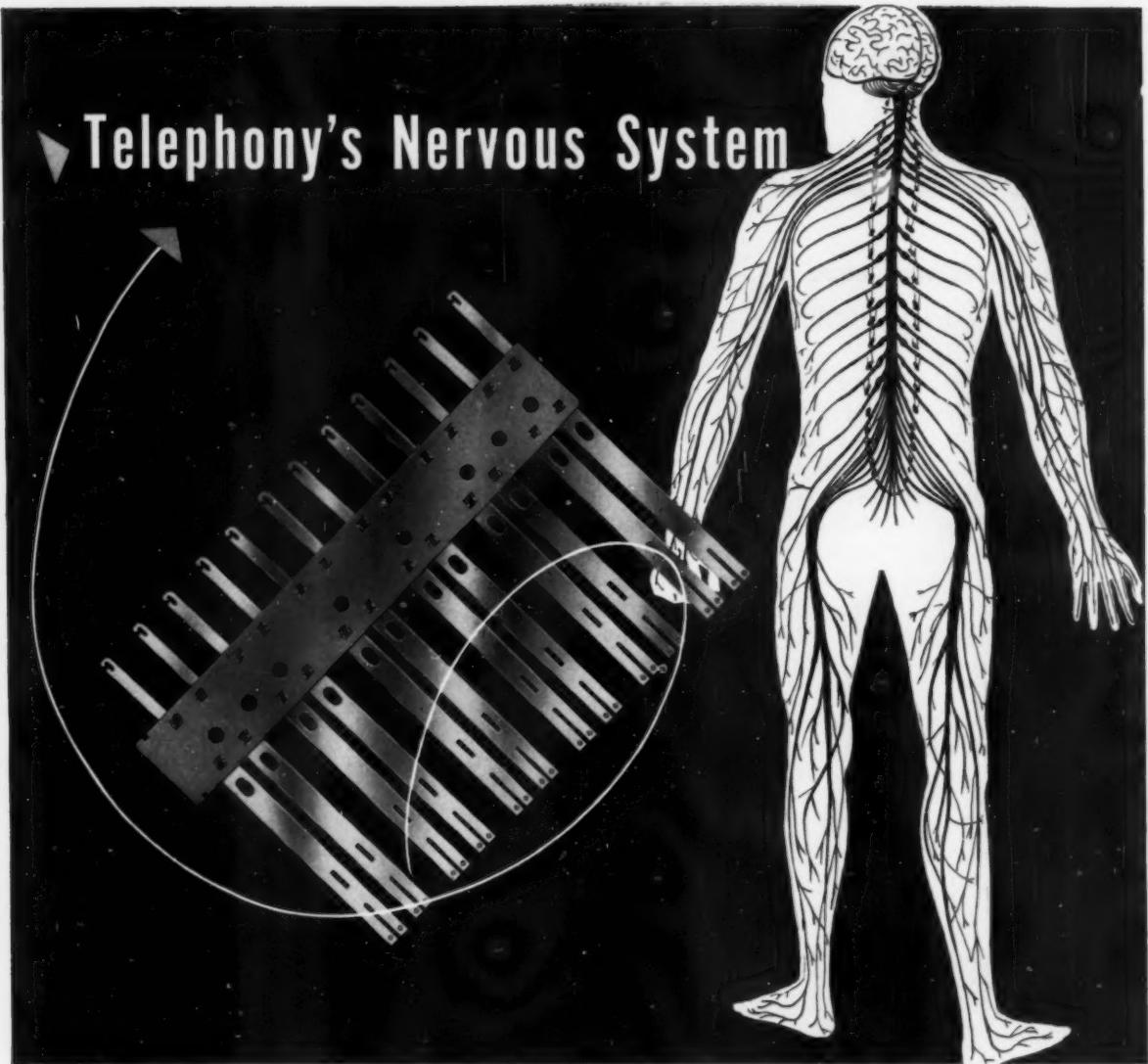
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Electronics & Instrumentation Division

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Testing machines • SR-4® strain gages • Transducers



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... relies on "neurons" of Seymour Nickel Silver

Dial telephones carry your voice to the ends of the earth through an intricate electrical network which closely resembles the human nervous system. Seymour nickel silver plays a key role in modern communications as part of the North Electric Company "Crossbar Switching System" which automates independent telephone company exchanges.

Tiny, neuron-like contacts on North Crossbar switch assemblies rely on flat springs of even-tempered Sey-

mour nickel silver for *trillions* of "makes-and-breaks".

Easy to work, corrosion-resistant and possessing excellent conductivity, Seymour nickel silver has an enviable reputation for quality and uniformity among hundreds of manufacturers who say: —

"Specify SEYMORE. You KNOW it's good!"

Perhaps Seymour metallurgists can help solve your materials problems. Tell us your requirements.

Long distance telephone operators link distant points to the North Crossbar System in Seymour, Indiana.



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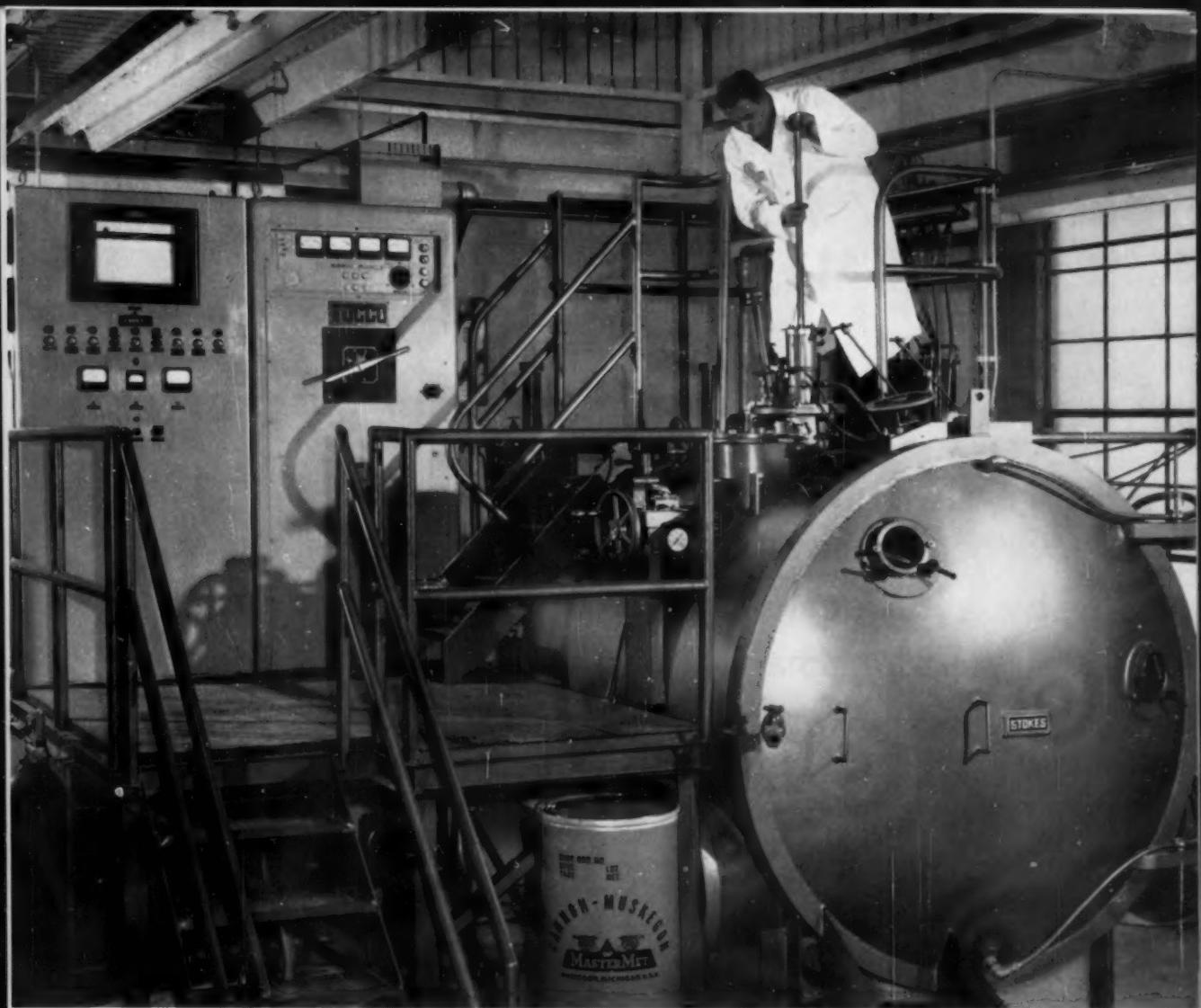
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"OLDEST AND LARGEST EXCLUSIVE MFRS. OF HEAT & CORROSION RESISTANT CASTINGS"

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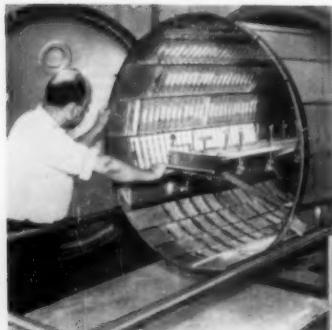
THE QUALITY NAMES IN ALLOY
FOR HEAT CORROSION ABRASION

X-ite



Due to Stokes vacuum lock design, operators can manipulate the melt during the heat without releasing vacuum. Furnace is used for production of special alloys at Cannon-Muskegon Corporation, Muskegon, Mich.

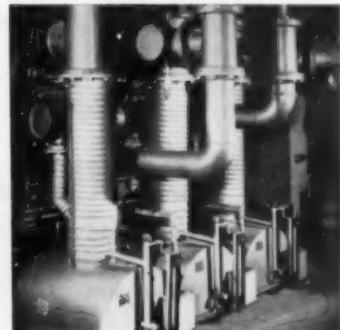
The metals industry is profiting from the use of other STOKES production equipment



Vacuum Metallizers. Stokes offers a complete line of vacuum metallizing equipment to plate metals for improved surface finish... also to provide conductive coatings on non-conductive materials.



Powder Metal Presses. Cost savings and the compacting of incompatible alloys have made powder metallurgy an accepted process. Stokes offers the most complete line of presses in the industry.



Vacuum Pumps. For rapid evacuation and holding high vacuums, Stokes offers mechanical pumps, and "Ring-Jet" oil vapor diffusion and booster pumps. New design affords 10 to 100% greater speeds.

"MasterMet" high temperature alloys vacuum melted in Stokes furnace

Another example of how Stokes vacuum furnaces aid industrial utilization of the new technology of vacuum metallurgy.

FOR the hot components of leading types of jet engines, Cannon-Muskegon produces a line of special vacuum melted alloys. Engineered primarily for high temperature service, these alloys are supplied as ingots and billets for investment casting.

A Stokes Vacuum Furnace provides performance to the exacting specifications required for this work. Its design is the result of close cooperation between Cannon-Muskegon and Stokes engineers. The furnace has a capacity of 500-pounds per heat.

In the words of George W. Cannon, Jr., company president, "The equipment has performed in accordance with our specifications . . . a leak rate of 8 microns per hour . . . and permits

pouring of vacuum alloys at pressures less than 10 microns."

If you are planning to explore the interesting potential of modern vacuum metallurgy, plan, too, to take advantage of the undisputed leadership in equipment and experience which Stokes can apply to your problem. Prime supplier of vacuum furnaces for production use, Stokes incorporates the features you need for simplified operation and dependable service. With the Stokes vacuum lock, you can make multiple melts and manipulate the melt without breaking the vacuum. High capacity pumping systems, combining new Stokes Ring-Jet Booster Pumps and rugged Microvac roughing pumps provide fast evacuation and dependable holding of desired vacuum.

A Stokes engineer will be glad to consult on your specific application, help you select the most suitable of the many basic Stokes designs for your work, and engineer modifications to your special requirements. For technical data, write for Stokes Catalog No. 790, "High Vacuum Furnaces."

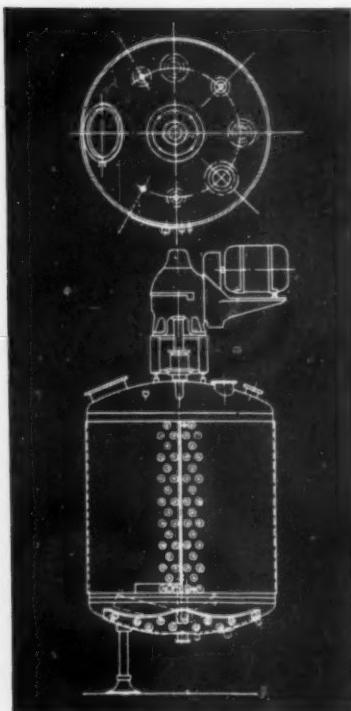
F. J. STOKES CORPORATION,
Vacuum Equipment Division, 5500 Tabor Road,
Philadelphia 20, Pa.

Reference Data:

- Microvac Pumps—Catalog 750
- Diffusion and Booster Pumps
- Specification and performance data
- Story of the Ring-Jet Pump
- How to Care for Your Vacuum Pump—
 Booklet 755
- Vacuum Furnaces—Catalog 790
- Vacuum Metallizing—Catalog 780
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Reactor unit of REM-CRU titanium built by the Pfaudler Co., Rochester, N. Y. and Elyria, Ohio a skilled fabricator of titanium and other corrosion-resistant materials.

	REM-CRU A-55 TITANIUM	METAL A	METAL B
Cost per lb.	\$14.60	\$0.8025	\$2.62
But titanium's light-weight means less is needed . . .			
Material Required	250 lbs.	785 lbs.	675 lbs.
So the comparative cost factor is reduced . . .			
Material Costs	\$3650.00	\$630.00	\$1768.00
Fabrication takes the lions' share, so . . .			
Cost of Finished Reactor	\$12,150.00	\$2391.00	\$4670.00
And in corrosive chlorides, hot acids, and many other environments, laboratory and service data show . . .			
Service Life	5 years	6 months	1 year
NOW . . .			
COST Per Service Year	\$2430.00	\$4782.00	\$4670.00

Don't be fooled by raw material costs alone—it's the *cost per service year that really counts*. Then, too, down-time losses while equipment is being replaced can quickly mount up. Another plus for longer-lasting titanium. Why not let a REM-CRU engineer help you make the best, most profitable use of titanium?

REM-CRU
TITANIUM

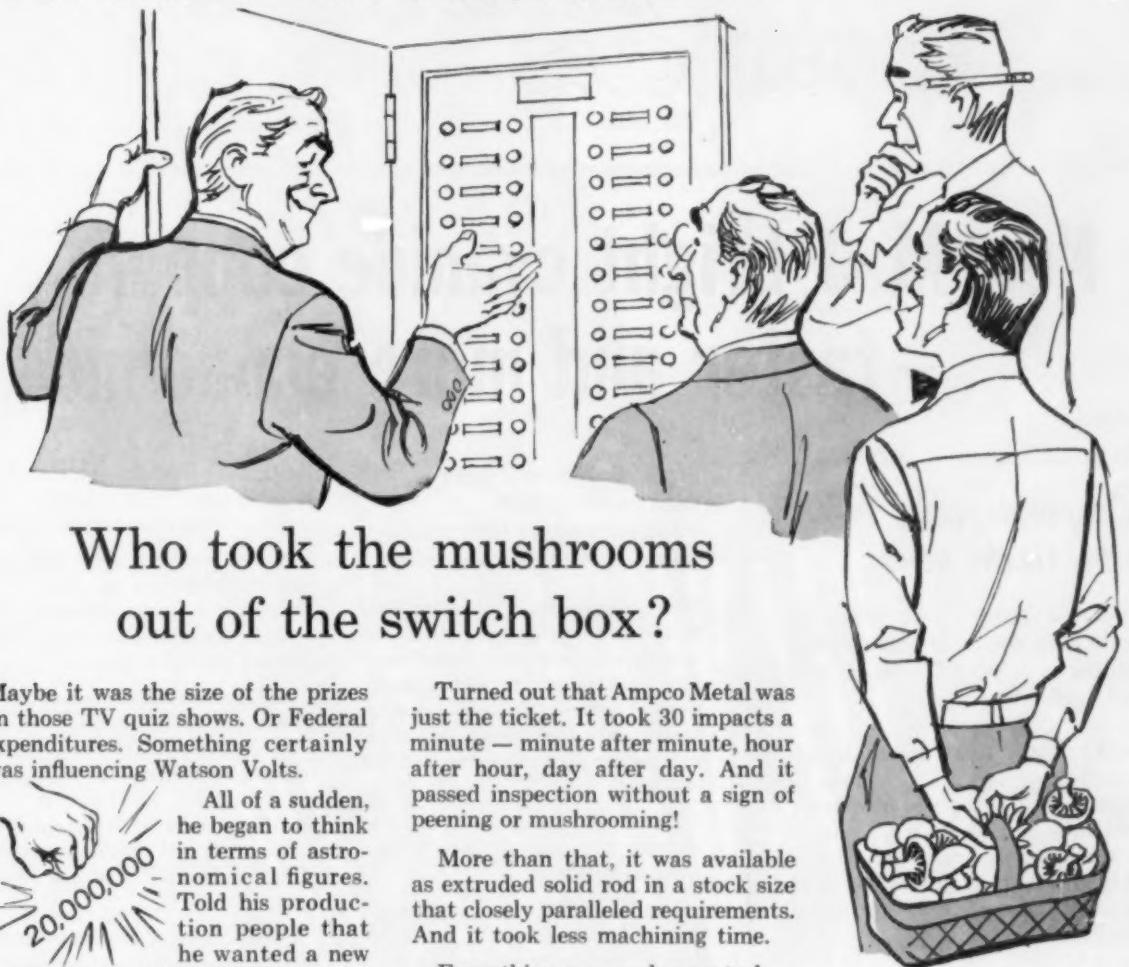
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Any similarity to a real-life company is purely intentional



Who took the mushrooms out of the switch box?

Maybe it was the size of the prizes on those TV quiz shows. Or Federal expenditures. Something certainly was influencing Watson Volts.

All of a sudden, he began to think in terms of astronomical figures. Told his production people that he wanted a new bumper for their electrical switch box. One that would take 20,000,000 (yep, that's right — twenty million) impacts! And do it without appreciable wear!

Like the hermit who saw a giraffe for the first time, the production manager said, "There ain't no such animal!" Suspecting, of course, that he'd eventually find that there was. Which he did.

Somewhere along the line, A Samaritan told the p.m. about Ampco Metal. About how it is a whole series of uniform-quality copper-base alloys engineered to meet a wide range of special-duty requirements.

Turned out that Ampco Metal was just the ticket. It took 30 impacts a minute — minute after minute, hour after hour, day after day. And it passed inspection without a sign of peening or mushrooming!

More than that, it was available as extruded solid rod in a stock size that closely paralleled requirements. And it took less machining time.

Everything was under control — including costs!

Ampco Metal = 
extruded solid rounds combine high strength and hardness with exceptional resistance to wear, fatigue, and corrosion.

Companies in many fields regularly use extruded solid rods of Ampco Metal — for bearings, bushings, worms, gears, and other vital parts.

Your Ampco stocking distributor can supply diameters from $\frac{1}{8}$ " to $5\frac{3}{8}$ ". Call him for prompt service. If you don't know who he is, write us for his name. **Ampco Metal, Inc., Dept. MP-11, Milwaukee 46, Wis.** (West Coast Plant: Burbank, Calif.)

AMPCO® METAL
The metal without an equal



UNICHROME
Trade Mark

News about
COATINGS for METALS

Metallic Organic Decorative Protective

New M&T bright cyanide copper — faster and more economical

Copper deposits now fit the need

Metal & Thermit now offers the most complete line of copper plating processes — has a deposit to meet all applications.

M&T "Golden Glow" Bronze is recommended for the optimum in speed, or throwing power to cover the most intricate work, or for a most attractive final finish. This is a copper-tin alloy process that is as easy to control as single metal plating.

Unichrome Pyrophosphate Copper stands out when density of deposit and smoothness are primary. It is preferred for such jobs as stop-off in nitriding, and for printed electrical circuits.

M&T Bright Cyanide Copper offers mirror brightness and excellent plating speed as an undercoat for decorative chromium finishes.

Bulletins available on each.

Unichrome is a trademark of Metal & Thermit Corp.

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CORPORATION

General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
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of Canada, Limited, Rexdale, Ont.

Metal & Thermit bath uses entirely new addition agents for stability, more dependable operation

Users report that the new M&T Bright Cyanide Copper reduces operating costs and assures uniformly high plating quality with a minimum of control. The low cost solution can be made up with potassium, sodium, or a combination of the two salts.

The cost of operation is low due to long life and stability of the addition agents.

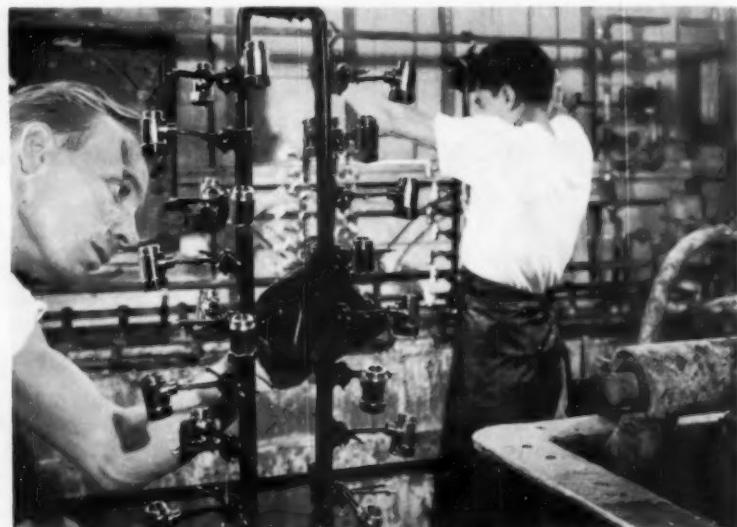
The deposits may be mirror-bright, if desired, or of a lesser degree of brightness, depending upon the specific requirements of each installation. The stability of the so-

lution has enabled platers to obtain brighter deposits with greater consistency than ever before.

A wide bright range at high cathode efficiency assures high rates of deposition without burning on edges or dullness in recessed areas. High current densities may be used.

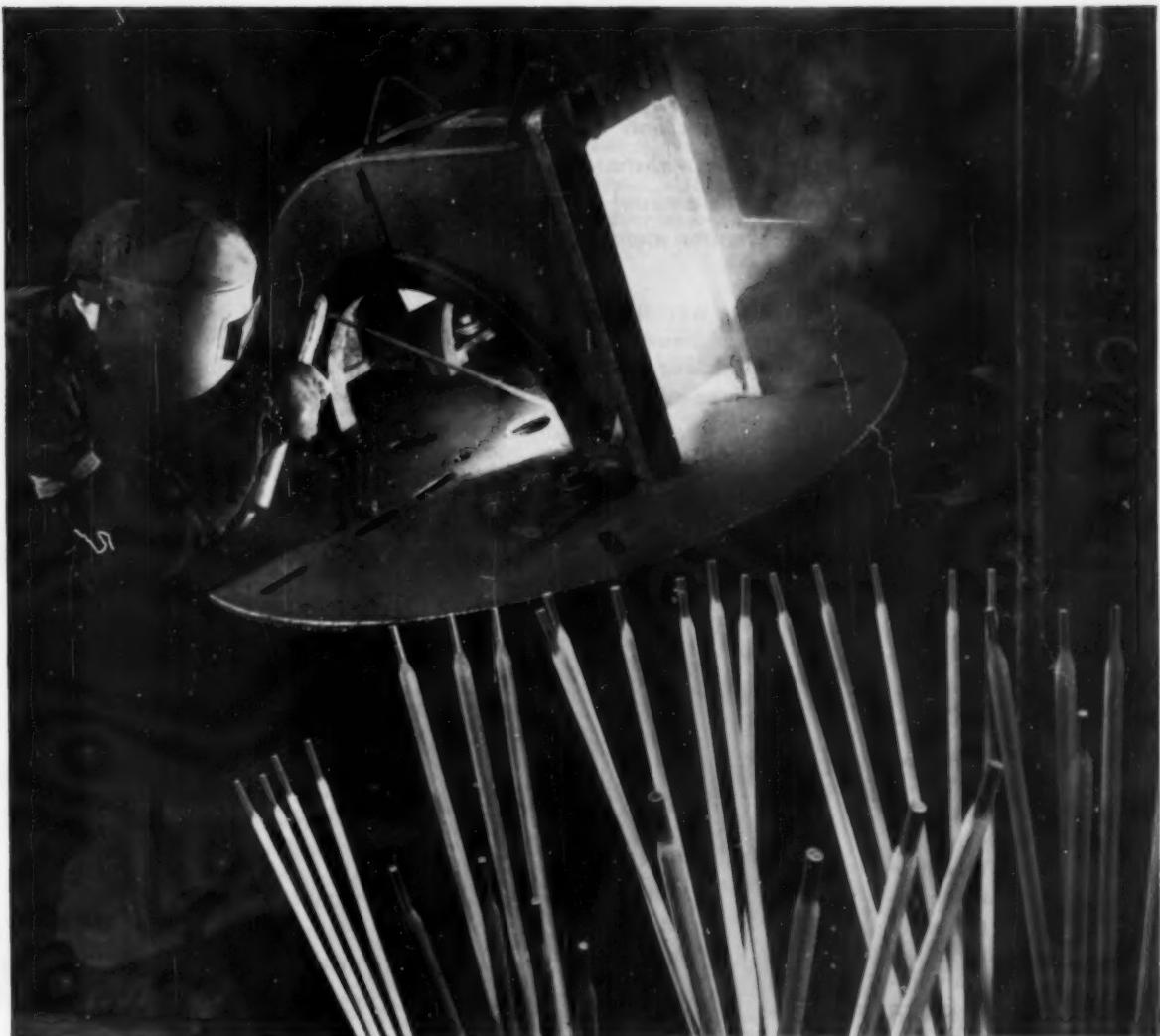
The process provides excellent anode corrosion, utilizing a new bath additive, NEOCHEL, which replaces Rochelle salts. The exceptional stability of this and other additives assures freedom from difficulty due to the accumulation of decomposition products in the bath.

Process control has been simplified. Only one chemical determination and a single Hull Cell test are required for control of the additives.



M&T Bright Cyanide Copper Process is already at work in sizable installations and a proved success.

Photo courtesy Pottstown Plating Works, Inc.



Why **P&H** Low-Hydrogen Electrodes eliminate costly rewelds on "difficult" steels

Alloy steels can be welded right the first time when you use P&H Low-Hydrogen electrodes. That's because the unmatched P&H electrode line is industry's largest — enables you to select the electrode that matches the chemical and physical properties of a wide range of problem steels.

This correct combination gives you better impact properties, faster deposition, and deeper penetration. Because these P&H electrodes prevent underbead cracking and porosity, you get high-quality x-ray

welds with little or no preheat and at much lower cost than is possible with higher-alloy electrodes.

To find out more about low-hydrogen electrodes, write to Dept. 324E, Harnischfeger Corporation, Milwaukee 46, Wisconsin, and ask for Bulletin R-26.

HARNISCHFEGER



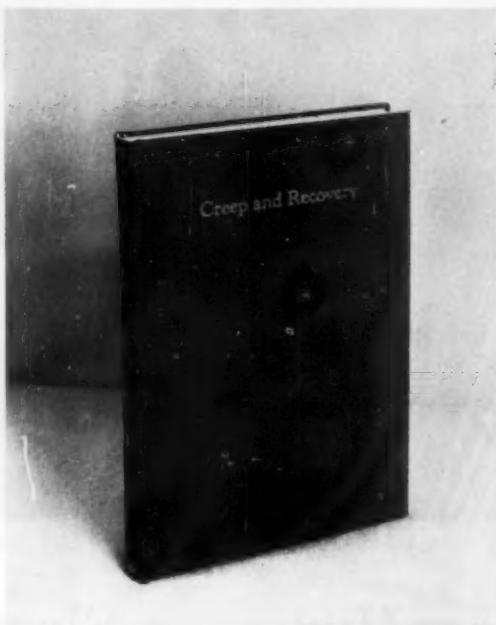
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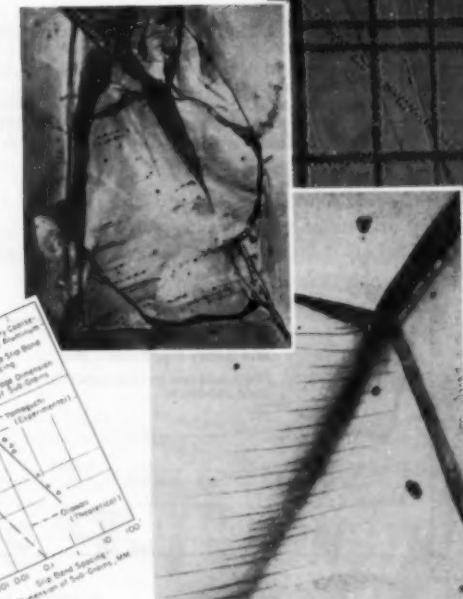
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HOW TO SELECT THE RIGHT METAL CLEANER FOR YOUR JOB

Selection of the right metal cleaner depends upon whether the cleaning is to be done in a power washer or soak tank, and whether electrolytic or emulsion cleaning is to be used. Also to be considered are the parts to be cleaned and whether inorganic or organic matter is to be removed.

While inorganic matter, which includes rust, scale and oxide, may be removed by either mechanical or chemical means, organic impurities—such as oil, grease and drawing compounds—are most effectively removed by chemical reaction.

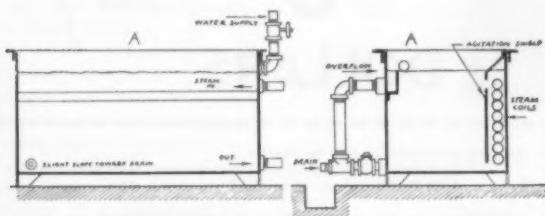
The method most widely used in heat-treating operations, for which Par-Kem Metal Cleaners were primarily formulated, is that which employs a hot-water solution of an alkaline metal cleaner. This method involves three general types of cleaning:

1. Cleaning in power washers.
2. Cleaning in still or agitated tanks.
3. Cleaning electrolytically.

The metal cleaners used for all three types of cleaning are basically the same. They are mixtures of alkalies and alkali salts—principally caustic soda, soda ash, phosphates and silicates—with or without a wetting agent added to improve emulsifying action.

The effectiveness with which the finished mixture performs its primary function of dirt removal depends upon which of these basic materials are used and in what proportions they are combined.

POWER WASHERS—With power washers, in which the cleaning solution is agitated by mechanical action, temperatures of 170-200°F. are recommended for alkaline cleaners, 140-160°F. for emulsion cleaners. In either case, only low concentrations of cleaner are required . . . which makes the power washer not only faster but somewhat more economical than other types.



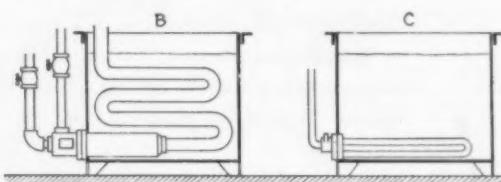
A typical steam-heated tank with overflow and agitation shield. Additional agitation may be obtained with propeller-type agitator, steam jets, or by mechanical or hand agitation of the work.

SOAK TANKS—Soak tanks require a somewhat higher concentration of cleaner than power washers, with temperatures of 180-212°F. With this type of equipment, heat and agitation are essential. The latter is provided by keeping the solution at a rolling boil, by blowing steam through the solution, or by using a mechanical or hand-operated type of agitator.

ELECTROLYTIC CLEANING—In electrolytic tanks, agitation is achieved by the evolution of gases generated by the electrochemical reaction that takes place at temperatures of 160-212°F. This type of cleaning involves three methods: cathodic, anodic, and a combination of the two.

In the first, the work is the cathode. This causes considerable more gassing and therefore better agitation. But it has the disadvantage of plating the work with any metallic impurities that may be present.

When the work is the anode, as in the second method, the danger of plating is eliminated but the surface of the parts is subject to attack. The third method is to clean cathodically first, then switch to anodic cleaning.



Cleaning tanks may also be heated by gas, as in Figure B . . . or by electricity, as in Figure C. Same means of agitation are employed as in the steam-heated tank.

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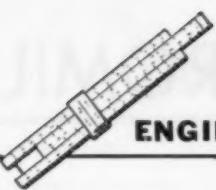
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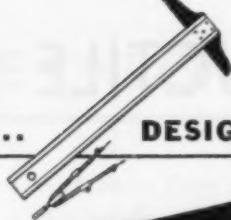
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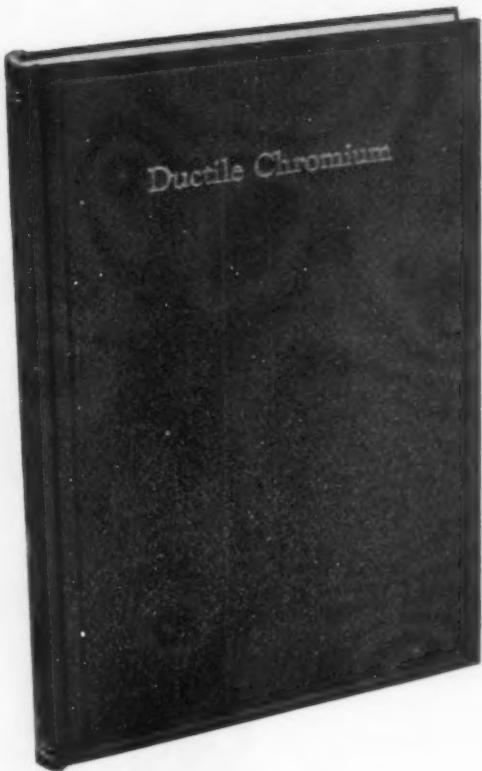
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THE SECOND SECTION deals with production of chromium metal, shows chromite resources of the United States by A. J. Kauffman, Jr., Division of Mineral Industries, Bureau of Mines, U. S. Department of the Interior; previous methods of producing chromium metal of commercial purity are discussed by F. H. Buttner, Electro Metallurgical Co.; first commercial plant for electrowinning chromium from trivalent salt solutions is described by M. C. Carosella and J. D. Mettler, of Electro Metallurgical Co.; fused salt electrolytic production of chromium is discussed by M. E. Silbert, B. C. Raynes and M. A. Steinberg, of Horizons, Inc.; cold-mold arc melting of chromium and chromium alloys is covered by R. A. Beall, G. Asai and A. H. Robertson, of U. S. Bureau of Mines; determination of oxygen, nitrogen and hydrogen in electrolytic chromium is discussed by R. M. Fowler, T. C. Lancaster and G. Porter, Electro Metallurgical Co.

SECTION THREE discusses ductile chromium metal, with properties of high-purity iodide chromium covered by R. J. Runch, T. E. Fearnside, J. M. Blocher and I. E. Campbell of Battelle Memorial Institute; mechanical properties of Bureau of Mines chromium by G. Asai and E. T. Hayes, U. S. Bureau of Mines; magnetic studies of chromium are presented by R. J. Weis of Ordnance Materials Research Office, Watertown Arsenal; effects of impurities on ductility of chromium are shown by W. H. Smith and A. U. Seybolt, General Electric Research Laboratory; melting point of high-purity chromium is discussed by L. L. Wyman and J. T. Sterling of National Bureau of Standards.

THE FOURTH SECTION shows the effect of gas on chromium metal with vacuum fusion gas analysis of high-purity chromium by J. T. Sterling, National Bureau of Standards and notes by G. S. Martin and G. R. Wilms, Defense Standards Laboratories of Australia; solubility of nitrogen and oxygen in solid chromium is described by D. Caplan, M. J. Fraser and A. A. Burr, Rensselaer Polytechnic Institute; volume change and gas evolution on heating electrolytic chromium discussed by K. A. Moon, Ordnance Materials Research Office and G. A. Consolazio, Watertown Arsenal Laboratories.

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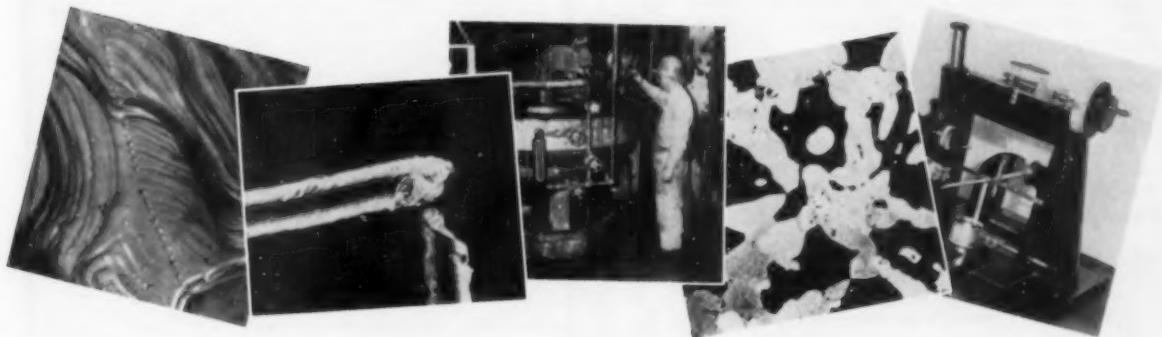
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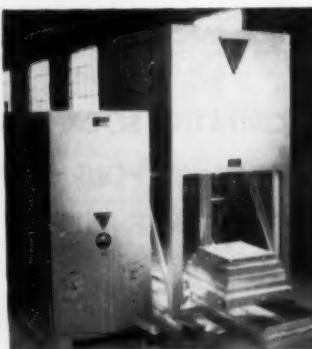
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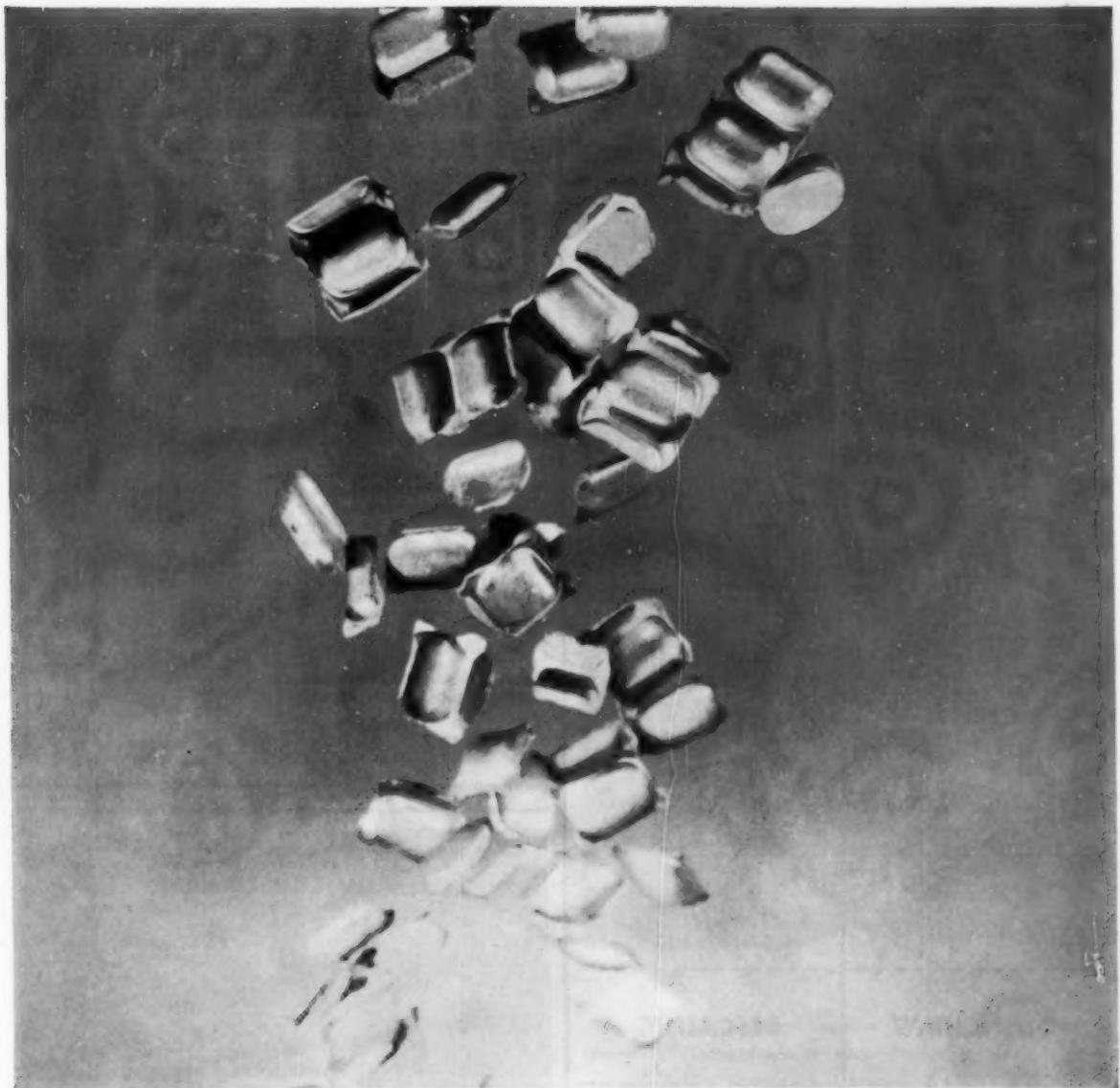
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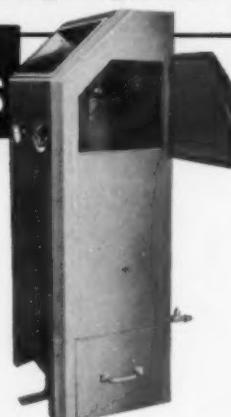
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New Roto-Pin type lock is integral part of all Pannier Supreme Holders... eliminates loose, bent, dropped, or lost pins... flip it open to change type... flip it back to securely lock type in clear-marking position.

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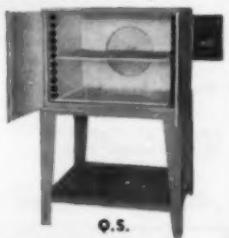
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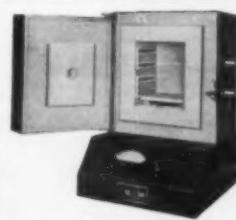
dyna-trol

Oven Model shown at right is only one in this size and price range with full multiple directed forced convection.



Q.S.

Model No.	Heating Chamber Dimensions Usable	Temperatures	Price
QS	28½" W x 28"D x 21½"H	225°	\$110.50
QL	28½" W x 28"D x 21½"H	325°	\$117.50
QM	24½" W x 19"H x 22"D	550°	\$333.50
QH	24"W x 16"H x 21"D	800°	\$595.00
QR	24"W x 16"H x 21"D	1000°	\$740.00



P-79

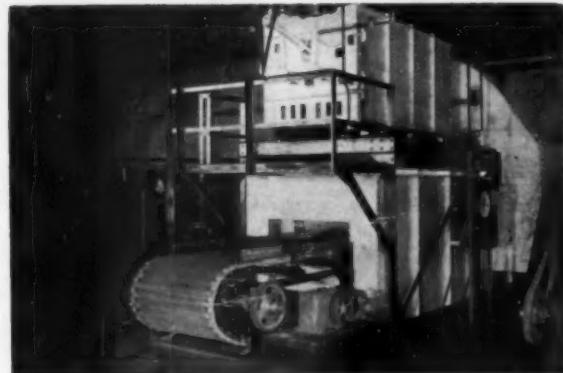
Heating Chamber Dimensions Usable
28½" W x 28"D x 21½"H
28½" W x 28"D x 21½"H
24½" W x 19"H x 22"D
24"W x 16"H x 21"D
24"W x 16"H x 21"D

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PRICE FROM
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UP

OVER 40 STANDARD MODELS AVAILABLE
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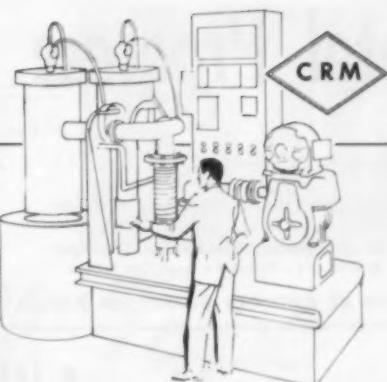
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effect large savings in drawing, tempering, ageing, and heat treating of such products as bearings, billets, springs, screws, tools, gears, etc. in steel or aluminum. Continuous operation at temperatures up to 1200° F. Temperature uniformity guaranteed! Gas, oil, or electric fired.

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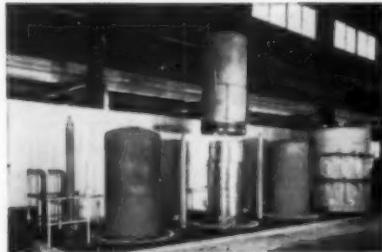


Part of an installation of large gas fired three-stack rectangular bell type forced circulation special atmosphere furnaces for annealing strip.



Bell Type FURNACES

Built to Suit Your Plant, Product or Process



Built right—over 20 years ago—this EF installation is still in operation, daily—and producing first class work.



EF direct gas fired forced circulation bell type furnace for processing wire, rod, strip and other products. The split cover design permits installing where head room is limited.

Single or multi-stack — circular, rectangular or square types — upright, elevator or partial pits — gas fired, oil fired or electric — correctly designed, built and installed, ready to produce.

Backed by over 40 years of practical furnace building experience, EF furnaces incorporate all the advantages of all bell type designs, for processing strip, wire, rod and other ferrous and non-ferrous products.

EF bell type furnaces installed over 20 years ago are still in service daily, producing first class work. After all, there's no substitute for experience. At your convenience EF experienced engineers will be pleased to discuss the best type for your specific requirements.



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GAS FIRED, OIL FIRED AND ELECTRIC FURNACES
FOR ANY PROCESS, PRODUCT OR PRODUCTION

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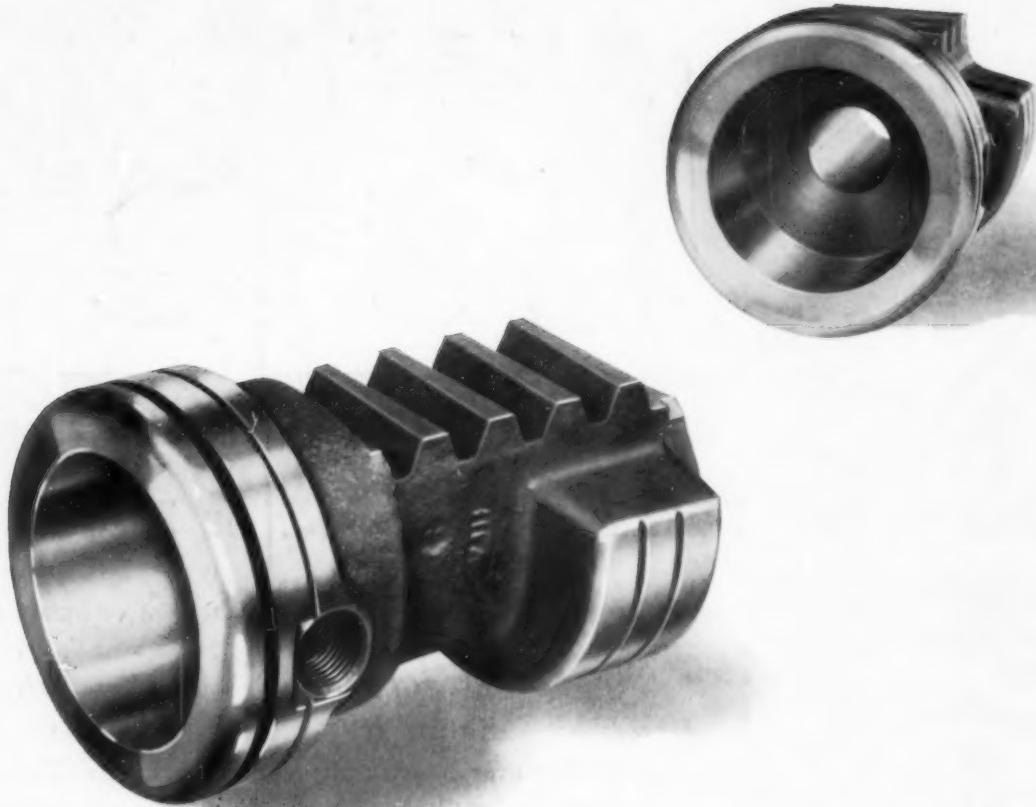
EF direct gas fired special atmosphere forced circulation, single stack circular bell steel strip annealers, each accommodates three 48" x 40" 15,000 lb. coils (45,000 lbs.)



Part of another installation of large EF gas fired three-stack rectangular bell type forced circulation special atmosphere furnaces for annealing steel strip.



EF gas fired special atmosphere rectangular bell type strip annealers with individually controlled forced circulation three-stack bases each with capacity of 135,000 lbs. per charge.



**TOOL LIFE SOARED FROM 25 TO 750 PIECES
WITH ARISTOLOY LEADED**

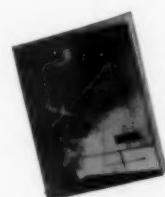
*Counterboring 8 lb. forging was costly
for large steering gear manufacturer*

Excessive tool breakage was running into hundreds of dollars per month for a large automobile parts manufacturer. On 2.17" ID counterboring operation of this forging made from A.I.S.I. 5120, chips were long and continuous. They wrapped around the tool, fouling it and causing premature tool failure. Tool life averaged only 25 pieces per tool.

A change to Leaded Aristoloy 5117 brought about an immediate im-

provement not only in tool life but in increased production and vastly improved finish. Tool life was upped to 750 pieces per tool. Spindle speed was increased from 113 to 239 R.P.M. and feed from .007 to .0134 I.P.R.

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